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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY,

ESTABLISHED NOVEMBER 13, 1807.

VOLUME THE THIRD.

Quod si cui mortalium cordi et curæ sit, non tantum inventis hærere, atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant.

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August 1, 1816.

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ERRATA.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY,

I. *Sketch of the Mineralogy of Sky,*

By JOHN MAC CULLOCH, M.D. F.L.S. President of the Geological Society, Chemist to the Ordnance, and Lecturer on Chemistry at the Royal Military Academy at Woolwich.

Read January 6, 1815.

A FEW weeks residence in the island of Sky having enabled me to give a general idea of its geological structure, I shall make no apology for offering this paper, however incomplete, to the Society. Want of further opportunities may perhaps for ever prevent me from rendering it more perfect, as it may equally prevent others from visiting that island. Nor is a district of such magnitude and interest, of which the distance is so great, and the inconveniences of climate and ground so considerable, likely soon to offer to others greater facilities than those, which enabled me to draw up this sketch. Should it prove otherwise, my object will at least, in its

principal view, be fulfilled, since I shall have opened a path for others to follow, and traced an outline which some more fortunate observer will with greater ease complete.

The variety of rocks which occurs in this island, as well as the theoretical difficulties in which the connection and order of many of these are still involved, and which are in some measure at least elucidated by their appearances here, render this island very interesting to the geologist. In attempting to describe them so as to give a clear topographic view of their situations, and at the same time to trace their connections with each other, (that object which is more peculiarly an essential part of geological science,) I have experienced difficulties which other observers must also have felt, and from which I have but imperfectly succeeded in extricating myself. It is to be hoped that our increasing knowledge will at some future day diminish, if not remove, these difficulties, and smooth the path for the future historians of the earth's surface and structure. In the mean time no greater impediment to the progress of that knowledge of which we are in search can be contrived, than that of assuming a certain regulated order, founded on imperfect and limited, or on prejudiced observations. This proceeding not only renders all investigation nugatory in itself, but accumulates by the establishment and diffusion of false canons, a constantly increasing load of obstruction to the progress of truth. The phenomena which have occurred to me in Scotland, during many years examination of that very instructive country, have so often led to conclusions different from those which have been supposed already established, as to compel my dissent from that system of general rules on which we have hitherto been taught to rely. At the same time, convinced that generalization on this subject was premature, and warned as much by my own discrepancies as by the

errors of those who have preceded me, I have rarely if ever attempted to draw such general conclusions. My chief endeavour has been to reduce questions of this nature to a narrow compass, where the limits admitted of contraction; and where any thing has appeared uncertain or contradictory, to put those uncertainties and contradictions in the clearest light, that future observers might direct their attention to those points which most stand in need of elucidation.

To place the subjects which have occurred in the examination of Sky, in an order as nearly as possible both conducive to topographical clearness and geological elucidation, I have varied the order of description as circumstances dictated. When the structure was simple, and the geographical details corresponded, the task has been easy to the writer, and will be easy to the reader. When it has been otherwise, I have attempted as far as possible to reconcile these claims; while in the greater number of instances, where the intricacy of the geological structure and the scattered disposition of the materials over a large extent of surface have prevented all possibility of reconciliation, I have been obliged in some measure to divide the subject with a reference to both these objects, preferring to incur the charge of prolixity rather than that of obscurity. I shall therefore commence by giving a general sketch of the several rocks which form the island, noting their geographical positions as accurately as circumstances permit; after which I shall attempt to trace their geological arrangement, entering more largely on those details which lead either to useful doubts or probable elucidation.

The want of accurate geodesic operations has left the form, dimensions, and position of Sky, as yet desiderata in British geography, an inconvenience however, much less in a geological view

than that which arises from the want of an accurate detailed map of its surface, its mountains, rivers, bays, and lakes; data, without which it is extremely difficult to give such particulars as could be desired of the situations, boundaries, and connections of its several rocks; a difficulty too not a little increased by the utter impossibility of obtaining the vernacular names from the natives, who are neither well informed on the subject nor very well agreed in their application. The want of ascertained distances and of fixed points of reference, arising from the vacant state of many tracts and the loose manner in which the Highlanders compute their miles, add not a little to the trouble of giving precise descriptions.

If we may trust to the latitudes and longitudes laid down, and they are the only documents on which we have to rely, the extreme length of this island is about forty-five miles, and its extreme breadth about twenty. Its form is that of an irregular parallelogram, so much intersected by deep sea lochs that scarcely any point on its surface is five miles distant from the sea. It is divided into geographical districts, which, as they bear some relation to the physical divisions of its surface, and will be necessary points of reference in describing its structure, I shall here enumerate.

Of these, the southernmost is the district and parish of Sleat, a tract of moderate and irregular elevation, terminating in the high group of mountains which approaches the main land, and which, in conjunction with Glen Elg, forms the narrow passage of the inner sound. This is bounded to the north by the parish of Strath, an open irregular valley, intersecting the island from N.E. to S.W. and separating the before-mentioned district from the remainder of the island, more particularly from the group of mountains which occupies its middle division. A tract of uneven land extends from Broadford along the eastern shore to the eastern Loch Eynort, and

over a high ridge to Sconser, where it ends at in Loch Sligachan, being bounded on its western side by the terminations of the before-mentioned group of mountains. The high hill forming the island of Scalpa is but barely separated by a narrow arm of the sea from this tract. An imaginary boundary drawn from Strath to the head of Loch Slapin on one side, and from Sconser to the western Loch Eynort on the other, includes part of the district of Minginish, and is still more remarkable as a physical division, since it contains the lofty and formidable group of the Cuchullin hills, with other mountains, of which the greater number are either nameless, or only recorded in the traditional geography of shepherds. This is the only part of Sky which can properly be called mountainous, and of which the aspect and character are perfectly distinct from those of the remainder of the island. The small district of Strathaird, more remarkable for its physical structure than its extent, is interposed to the south of this tract, lying between Loch Slapin and Loch Scavig. The northern and larger division of the island which exhibits a great uniformity of physical character considerably distinct from those now enumerated, contains the extensive districts of Trotternish, Vaternish and Bracadale, the former occupying the eastern and the two latter the western side of the island.

The whole of this tract is hilly and uneven, yet cannot be considered as mountainous, except perhaps on its eastern side, where one irregularly elevated and continuous ridge extends from Portree to Ruhunish. Some high ground also occurs about Dunvegan, but the rest is an undulating tract of hill and moor country.

The indentations which form the sea lochs are in some cases determined as on the continental land, by the vallies which are interposed between ridges of hills, and in this case they are also the aestuaries of the rivers. But many of them are merely sinuosities of the

general boundary, receiving no streams of magnitude. To the former belong the narrow lochs Slapin, Scavig, Brittle, Harpart, Eynort, Eishort, Sligachan, and Portree; lochs Bracadale, Follart, and Snizort, belong to the latter.

Although the elevation of the country is considerable, and the climate among the most rainy of this kingdom, Sky affords no rivers of magnitude: their course is too short to admit of the accumulation of large streams. The river which runs into loch Sligachan carries more water to the sea than any other, and after it perhaps follow in order those which run into the lochs Harpart, Slapin, Eishort, Bracadale, Portree, Snizort, and Broadford. The other streams are rivulets scarcely worthy of enumeration. The drainage of the whole country is determined by the positions of the hills and sea lochs, and may readily be collected from the preceding observations. There are three or four fresh-water lakes, but of small size, and, except those of Coruisk and Colmkill, hardly worthy of the name. The courses of these streams exhibit but small traces of the wasting of the land. Like other mountain torrents they bring down at times rubbish and stones, but these bear no proportion to those accumulations of loose matter so common on the main land, nor do they offer any example of transported materials of which the origin is not to be traced to some neighbouring rock.

The surface of Sky appears at first sight one continued tract of brown moor, a dreary region of heath, and rock, and bog. Rugged mountains exhibiting naked spires of bare rock of which the sides are covered with ruins, lofty cliffs whose bases are whitened by a boisterous sea, a stormy atmosphere with almost incessant rains, complete the wild picture which first meets the eye of a stranger. Yet a more intimate acquaintance discovers scenes of grandeur and

sublimity exceeded by no part of Scotland, abounding as it does in the picturesque and romantic, and a more accurate survey of the island shows spots with a fertility and population surpassed by few of the highland districts; together with a climate nearly as mild, and a temperature as equable as that of the western parts of England.

The district of Sleat, consisting of decomposed schistus, possesses along its eastern shore a highly fertile tract with an excellent and deep soil, adapted to the growth of all kinds of grain, and displaying pastures of perennial verdure. Similarly fertile soils are found in the vallies on its western side, while the central division, formed of syenite or quartz rock, produces the usual covering of those rocks, heath. In Strathaird, nearly the whole peninsula of which consists of secondary strata, we find a soil as fertile as we should expect on such a basis and in such a climate; a soil however owing less to art than to nature, whose bountiful efforts are seldom much assisted by highland industry or knowledge. A great part of the district of Strath lies on a bed of limestone, and appears from its natural grasses and its general aspect to possess all the requisites for culture, or at least for an improved system of pasturage. But it has hitherto been much neglected, and remains an almost useless tract of wasted and scanty herbage encumbered with rocks and stones, undrained, unfenced, and untilled.

Nature may be said to have denied a soil to the mountain tract which I have before described as forming the centre of the island, and these hills adapted for no other system are imperfectly occupied by sheep, of which from their rocky and sterile nature they can maintain however but a scanty proportion. A few stags yet remaining in these almost inaccessible regions divide with them this barren range. The lower pastures are more advantageously occupied by the

well known and celebrated breed of black cattle which forms the staple produce of Sky.

The stony district about the Kyle ric'h produces like the Cuchullin hills but a scanty covering of heath and grass, and is perhaps among the most unproductive of the island, since the decomposed quartz rock of which it consists, yields a soil even worse than the syenite of the Red hills, or the rocks of the Cuchullin group; yet on the sea shores a few fertile spots are found in cultivation.

The great northern division consists of one entire mass of trap, with the exception of a few narrow lines of limestone and sandstone to be found on some of the shores. In various parts of this tract there are to be seen districts of considerable fertility, admitting, under the highland system of cultivation, a perpetual rotation of corn, with no alternation of green crops or fallow except the occasional one of potatoes; the hay as is usual under the same system of farming being collected from wet meadows and waste patches of land. The most considerable of these corn districts is in Trotternish, which for many miles displays an extent of cultivation exceeded by few highland tracts, and is emphatically called the granary of Sky. The aspect of loch Uig under the new crofting system is in this respect highly interesting. In various parts of the sea shore about loch Snizort and loch Follart, as well as in the vicinity of loch Bracadale, similar fertile tracts occur, and the little retired valley of Talisker might in a drier climate compare in fertility with the most chosen spots of our own southern counties.

Since chemistry has lately, although perhaps hitherto with little success, lent its speculative aids to the improvement of agriculture, it will not be foreign to the views of the geologist to examine how far his science also may bear upon this first and fundamental of all

arts. From the identity of rocks in different tracts a conclusion may be drawn with regard to the identity of the resulting soils, and the analogies discovered in them may perhaps with less trouble and as great certainty as any chemical analyses, lead agriculturists to hazard those experiments in improvement which seem justifiable from similarity of composition no less than similarity of climate and exposure. I shall therefore I trust be excused for dwelling a little longer on a subject intimately connected with geological science, and in itself among the most practically interesting that can occupy our attention.

It is already well known that many of the rocks of the trap family, like some lavas, afford on decomposition one of the most fertile soils with which we are acquainted. On former occasions I have mentioned this fact, and noticed at the same time the great differences which appeared in this respect in different situations where there was nevertheless a considerable resemblance in the rocky substratum. The different proportions of calcareous earth, of alkali, and of carbon, which latter appears to be an ingredient in some traps, are probably the circumstances which constitute the chief differences in this case; but with this we must also consider that the various rocks of this class differ in composition in perhaps a greater degree than any others with which we are acquainted, and that together with this essential variation in their composition, they also possess infinite varieties in hardness, and in the property of decomposing by the action of air and water. Many considerations must therefore enter into our views before we can decide on the fertility of the resulting soil, unless it be actually exhibited in those places where decomposition has already taken place.

In the district of Sky which I am now considering, there appears, as far as an accurate mineralogical investigation can determine such

a point without the aid of analysis, a considerable similarity of composition in the trap throughout the greatest part of the whole tract. In almost every place where the rock approaches the surface, it is found on cutting into it to be rotten to a considerable depth, often reduced superficially to an absolute soil, and although appearing below like a solid rock, capable of being cut without difficulty by the pick-axe or spade. Occasionally it decomposes into a soil perhaps more gravelly in some situations than in others, but in this case there appear only time and a further continuance of the destroying powers requisite for its complete change. Where the decomposition is most perfect it forms a clayey loam of which the aspect at least is favourable, and of which the fertility also is probably not so limited as the appearance of the heath and grasses which it bears would at first sight induce us to believe. The trap which I have mentioned is remarkable for the enormous quantity of zeolites imbedded in it, the mineralogical details of which I shall have occasion to speak more largely of hereafter. In the decomposed soils these are frequently found resisting change long after the rock is rotten and reduced to clay. But in many other cases they also are decomposed together with the soil, and in such quantity as to communicate their white colour to it, and with that colour doubtless a degree of additional fertility derived from the quantity of calcareous earth which they contain. In many places such accumulated beds of decomposed zeolites occur that they have been mistaken for marl, and have when used produced similar effects; although the narrow and slovenly system of cultivation practised by these little highland farmers neither admits of a full trial nor of a fair result.

We have seen that many tracts of this district are characterized by a high degree of actual fertility, while neighbouring ones formed of a soil apparently identical and under similar circumstances of cli-

mate and exposure, are still covered with unprofitable heath and peat, producing a scanty and almost useless herbage. It is worth our while to inquire into the causes of this difference, and to see if valid ones cannot be assigned.

In the land already under tillage it is obvious that the subsoil is covered with a soil actually in use, consisting of vegetable mould annually loosened by the spade or plough, and admitting the penetration of light, of air, and of water, to the subjacent and half decomposed matter. In the uncultivated neighbouring tracts we shall on the contrary find it covered with a thick mass of peat, the immediate soil on which the heath, the sphagnum, the carices, and the rushes alternately flourish and die, adding fresh matter to this already impenetrable substance. Neither air, light, nor water can make their way through this dense covering of a substance so notoriously impervious that it has been found of equal use with clay in puddling the artificial banks of canals. It forms in fact an adventitious and useless soil so entire and so impenetrable that it would be of equally little consequence to the land-owner in its present state, whether it were bedded on a rock of solid quartz or on the most fertile garden mould. Fortunately this covering of peat is rarely so deep that the plough or the *caschrom* (the crooked spade of the Highlanders) cannot reach to the bottom of it. The remedy and obvious method of improvement is pointed out by the relative condition of the fertile and the barren parts of this tract. The few experiments which have been tried have proved eminently successful, and among them I may point out those performed by Mr. Macpherson at Portree. By the admission of air and water the progress of decomposition is accelerated, and the rock is reduced in no long space to a useful soil. The texture of the peat is at the same time loosened by its admixture with the decomposed rock, and being thus

preserved in an open state and subjected to the changes which pulverization and access of air always produce on it, adds the carbonaceous ingredient to the clay, and forms a true vegetable mould. It is a separate question depending on various other considerations, whether this species of improvement should in all cases be directed to the cultivation of grain; but there is no doubt that it could be easily turned to a system of ameliorated pasturage, a system under which, without exaggeration, one acre of land could be made to produce more than many hundreds in its present state.

It is not my business to inquire into the obstacles which impede this obvious improvement of a country possessing such capability. Want of capital may be one cause, but it is more probable that the chief impediments are of a moral nature, resulting partly from the characteristic indolence and contentedness of the inhabitants, and partly from the difficulties which always attend the introduction of novelty into practices long established.

The want of trees in this island must be attributed to similar causes, since they would grow well in innumerable sheltered situations, and since some parts of the island still exhibit the remains of ancient woods.

In mentioning the artificial divisions of Sky, I have already touched slightly on its general irregularities and the disposition of its surface, but as these are intimately connected with the arrangement of its rocks, they require a more detailed consideration.

The principal group of mountains is that of the Culin or Cuchullin, so named from the well known traditional hero and king of this island. This forms an irregular mountain tract covering an area of ten or twelve miles by seven, and skirting the sea shore with a very bold series of declivities from near Loch Eynort to Loch Scavig. The single mountain Blaven forming a long ridge between the lochs

of Scavig and Slapin, may be classed with this group of the Cuchullin, as it resembles it in altitude and aspect as well as in mineral composition, and thus adds about ten more square miles to the space occupied by the particular class of rocks of which this group is composed. The whole of this compound group is strongly distinguished from the associated and neighbouring mountains, as well as from all the other mountains of Scotland, by the spiry and rugged forms of its outline, which presents a series of naked rocks and towering cliffs destitute of vegetation, and rising dark through the mists which seem for ever to hang on its stormy summit. The mountains of Arran, alpine and serrated as they are, bear no comparison with them, and the far famed scenery of Glenco almost sinks into insignificance before the terrific grandeur of the Cuchullin hills.

It is to be regretted that no observations have yet been made to determine the altitude of this group; a want which I was unfortunately in no condition to supply: but from that sort of experience in the elevations of hills which is acquired by long habitude in a mountainous country, and by comparing them with ascertained elevations from different points of view, a rough estimate may be formed of its altitude, which must at least suffice till some more fortunate traveller shall place his barometer on the summit. They do not fall short of three thousand feet, and in all probability exceed it. A general idea of their ground plan may be conveyed by saying, that they form an irregular and curved ridge of a very intricate shape, giving rise to numerous streams, the waters of which, for the most part, are discharged into the western sea; this proceeds from the inclination of the hills, the principal escarpements of which, however irregular, look towards the east and north.

This group is intimately connected with another, which for the

sake of perspicuity I shall distinguish by the name of the Red hills, a name very characteristic of their colour as contrasted with the livid black of the Cuchullin, and excusable in as much as it is applied by the natives to some of the principal hills of the group. I would gladly have given the name of each individual, but I was unable to procure them, no general surveys having been made, and the particular surveys of estates, either neglecting to notice them, or, like the shepherds, differing so much in opinion as to lead to inextricable confusion. Fortunately it is not material, as their uniformity of structure is so great, that the description of one is nearly applicable to the whole of the group. The general outline of these hills forms a character as highly contrasted to that of the Cuchullin as are their respective colours. In place of the lofty spires, the impending precipices and the almost unalterable rocks of those, we see in the Red hills a continued succession of tame rounded outlines, the effect of a decomposition which has covered them with ruins and almost every where concealed from view the natural rock. They also fall far short of the Cuchullin in elevation. Those which are entirely red, and which, as will be hereafter seen, consist of a syenitic rock, do not approach, within many hundred feet, the height of the former, and the loftiest of the group, among which that of Glamich takes precedence, will be found to consist of a mixture of the syenitic rock, and that clinkstone, which, as I shall hereafter show, constitutes a portion of the mass of the Cuchullin.

Comparing from the summits of any of the hills the general aspect of the two groups, the spectator is inevitably struck with the different powers of resistance which the two classes of rock offer to the efforts of time, and looks forward perhaps to a distant day when the red hills shall be levelled with the land below, while the Cuchullin shall still lift its iron summit to the clouds. There is yet another charac-

teristic difference between the two groups. We have seen that the Cuchullin and Blaven form one irregular mass, continuous in the ridges and much confounded both with each other and the general mass of the island. But the Red hills form rather a distinct assemblage of mountains, being separated either singly or in small associations by deep vallies, and placed as it were upon the general level. This group is bounded on the west by the vale of Strath, which extends from Broadford to the head of Loch Slapin, and skirting the sound of Scalpa terminates at Loch Sligachan. I may add that except the slight mixture of substances which appears to take place in Glamich hill, and in one or two more of those which come into contact with the Cuchullin and with Blaven, these two groups do not interfere, but are composed respectively of different and well characterized rocks.

The great mountain of Blaven is skirted by lower hills, descending gradually into the table land of Strathaird, which we shall hereafter see to be the largest portion of the secondary stratified rocks existing in Sky.

An uneven land, rising into irregular low hills, occupies the whole tract to the southward of the valley of Strath, with the exception of a nook which may be defined by an imaginary curved line drawn from Loch Oransa to the castle of Inverfuchag. This part of the island forms another distinct mountain group rising into two principal summits, and attaining an elevation apparently of fifteen or eighteen hundred feet.

The general elevations of the remainder of the island may be discussed in a few words.

Having passed Loch Sligachan, an irregular ridge of high land appears branching in two directions. The main ridge occupies the eastern side of the island to Portree, where it is interrupted by the

harbour of that place. Resuming thence its northern direction it continues to rise gradually for twelve or fifteen miles, and declines as gradually to the northern extremity of the island at Ruhunish. This ridge shows a gentle declivity to the west while to the east it frequently presents a rocky and broken escarpement. As far as its elevation can be estimated by the aspect of the view from its summit, and by comparing it with other known elevations when seen from the sea, it seems to reach at least the height of fifteen hundred feet. It may even be more considerable, since the gradual ascent of the land around it tends to make it appear lower than it really is.

As the abrupt face of this ridge is directed eastward, it thus forms a second and interior range of cliffs which in many places rises to a considerable height. The most remarkable of these is to be seen at the Storr, from whence it extends for some space northwards. The precipices which form the eastern face of the Storr offer scenes to the lover of the picturesque not exceeded either in singularity or grandeur by any thing which is to be seen in Scotland, and almost as little known to the natives as to casual travellers. In the progress of decomposition vast fragments have been detached from the body of the hill, and continue insulated on its slope, resembling at a little distance the remains of ancient castles and the spires of ruined cathedrals. One remarkable conical rock attains a height of about an hundred and fifty feet, its base not exceeding twenty in diameter, forming a sea mark as conspicuous to the vessels which frequent this coast, as it is striking in a picturesque view.

The mineralogist, no less than the admirer of fine nature, will be gratified by the examination of the Storr. It consists of an amygdaloidal rock, containing abundant specimens of the zeolite family,

which I shall have occasion to describe in their proper place. The other ridge which I mentioned as branching from it, is considerably lower, and consists in fact of uneven undulating ground, stretching away to the north-west till it reaches Vaternish point. The western peninsular division, from Dunvegan head to Macleod's Maidens, is a tract of high land containing the two remarkable flat topped mountains known by the name of Macleod's Tables, the height of which appears to be similar to that of the great eastern ridge. What remains of the island is one irregular table land, offering hills which in any other situation would appear considerable, but which lose their importance in the vicinity of the towering Cuchullin.

I have reason to think that in the general estimate here given of the elevations in Sky I have fallen short instead of exceeding, and shall be glad if future observers shall determine these altitudes with correctness. I scarcely however consider it in any other light than as a question of geography, as the increased examination of geological phenomena has proved that there is no general or necessary connection between formations of particular rocks and given elevations. Equally unfounded appear those rules which have, as recent observations show, been prematurely laid down respecting the *outgoings* as they have been called of the several classes of rock. The irregularities of these *outgoings*, not only absolutely but relatively, seem to point out to geologists a department requiring at least a very careful review, if not an absolute elision from the laws of the science.

I have nothing to add to the description of the rivers which I gave in speaking of the geographic divisions of the island, and the remarks I have to make on the waste of the land will be comprised in a short space.

I have already said that I did not observe in any part of Sky those accumulations of foreign and transported materials which are of such frequent occurrence on the main land of Scotland, and of which I have already noticed a remarkable example in Staffa. The accumulations of matter which it offers in several places are but trifling, and they are evidently derived from the daily action of the rivers, or from the ruin of the exposed rocks.

Commencing at Loch Slapin a considerable alluvium may be observed occupying the head of this Loch and extending up Strathmore, encroaching on the top of the bay, and evidently formed by the waste of the Red hills, with additions comparatively insignificant from the naked precipices of Blaven.

As the upper end of Loch Eishort receives no river of note, it presents no alluvial deposit, and no further marks of waste, encroachment, or alteration of the sea line, are to be observed round the point of Sleat till we reach Loch Oransa. Partial depositions of gravel may be traced from hence round the shore to Kyleaken, where a considerable bank of alluvial matter has been thrown up, apparently from the concurring action of the rapid tides which run through the sound of Sky. Opposite the island of Scalpa a sort of *delta* has been formed, which bids fair at some future day to unite the two islands into one. The head of the eastern Loch Eynort is also the receptacle of considerable masses of rubbish brought down from the Red hills, a waste sufficiently great to alter the courses of the small streams which run through the narrow vallies separating these hills. Similar, but more extensive, accumulations from the same cause have formed a tract of plain ground at the head of Loch Sligachan, subject to frequent inroads and changes from the still varying course of the stream. The waste of the land which

supplies the river running into Portree harbour appears to have had some effect in filling up its southern branch which the ebb of the loch has no tendency to remove. From below Portree to the northern point of the island, the coast consists of high cliffs of trap, which exhibit the species of decomposition characteristic of these rocks, in the vast slopes which decline from them to the shore wherever the action of the tide has not been sufficient to prevent that accumulation. Continuing round the point of Ruhunish, similar cliffs of trap resting on the secondary strata extend to the bottom of Loch Snizort, at the end of which as well as of Loch Uig the same appearances of encroachment are visible. The parish of Kilmuir offers the only considerable tract of alluvial land in Sky, from which its superior and long established fertility is probably to be accounted for. I cannot speak positively of the shores which form the point of Vaternish, having only seen them from a distance, but as they resemble both in aspect and composition the division of Trotternish just noticed, it is probable they possess no great peculiarity in this respect. Neither does Dunvegan offer any thing worthy of remark.

The shores of Loch Bracadale exhibit when low, considerable portions of clayey alluvial soil, characterised like those of Kilmuir by extraordinary fertility. A similar alluvium may be observed at the head of Loch Harpart, and the little valley of Talisker appears to have been entirely gained from the sea at some distant period, by a combination of the waste of the land with the counteracting efforts of the western swell, which has thus formed a natural embankment for its further protection.

A remarkable difference is to be seen along the whole western shore of the island from Dunvegan head to Loch Brittle, between

the effects of the eastern and the western sea. I already observed that the eastern cliffs were covered by a slope of alluvial ground descending to the sea; but the western, though formed of the same rocks, offer an almost continued precipice, the foot of which is every where washed by a turbulent swell. These cliffs are in a state of daily ruin, and their bases are beset with enormous masses of rock which from time to time fall from them. The rocks called Macleod's Maidens, the islands in Loch Bracadale, and other detached rocks which skirt this coast, mark equally the gradual waste of the land. But no slope is formed against their faces, nor does any artificial shore accumulate at their feet, except a narrow and almost impassable interrupted stripe composed of fragments. The smaller pieces and the *detritus* of these larger ones, are probably carried away from the coast by the incessant action of the western swell far into the depths of the sea. As there are no recorded soundings of this shore, I cannot confirm this supposition by any account of the nature of the bottom. But it will not be out of place to enter into a more particular detail of this line.

The coast of Sky from Dunvegan head to the entrance of Loch Brittle is, with but few exceptions, formed of high cliffs; variable however in their altitudes as in their abruptness, but generally very lofty and very abrupt, nay often precipitous and perpendicular from their summits to the water's edge. It is unnecessary to note any but the most remarkable points, as there is a great general resemblance throughout the whole. Between Dunvegan head and Loch Bracadale they are often perpendicular, but variable in height, and seldom attain the great elevation which they reach between Talisker and Loch Eynort. There, as in many other places, they

possess a singularly striped appearance from the great variety of colours in the several beds which compose them, of which twelve or more may in different places be counted, all horizontal and tolerably equal in their dimensions. The forms of these cliffs are far too monotonous and too square to afford subjects for the pencil, every part being marked by a general similarity of character. Near the entrance of Loch Bracadale some variety is presented by the three detached and pyramidal rocks called Macleod's Maidens, the highest of which appears to reach to about 200 feet. This feature, of detached pyramidal masses, is of frequent occurrence on this coast, a remarkable perforated one being seen in Loch Bracadale, and a similar one not far from Loch Eynort. They are, like all other objects out of the ordinary course of nature, rather singular than picturesque: the strange and the bizarre are seldom legitimate subjects for painting, and rarely please long, after the first wonder has subsided.

In Loch Bracadale some caves are found in the rocks, which have no particular claims on notice either from their beauty, their magnitude, or their singularity. Similar caves are of frequent occurrence between Talisker and Loch Brittle, the low projecting rocks being also often perforated by arches which are sometimes exceedingly complicated and remarkable. With the exception of some projecting points of high rock the shores of Loch Bracadale are flat, and this tract is among the most fertile of Sky. At its southern extremity the cliffs are perfectly vertical, and without that slope at the foot, which so commonly accompanies the high cliffs of trap, and which are so conspicuous in particular on the eastern side of the island. The retired and green valley of Talisker opens to the sea by a low beach, on which the natural embankment already mentioned has been formed by the western swell. Here

the cliffs again become high, and shortly rise to the greatest altitude which they attain along the whole line of this coast. In a general sense they may be called perpendicular, but they are seldom without grassy slopes either at their feet or in some intermediate parts, which diminish their vertical appearance when seen in profile, although when viewed in front they still appear perpendicular. The outline is here more varied, the parts more numerous and intricate, and the tone of colour more agreeable, while the foregrounds, which are formed by some high and conspicuous detached rocks, produce with them some of the most magnificent compositions of rock scenery which are to be seen on the coasts of Sky. Not far from this place is a large and very remarkable slide, by which a considerable portion of the cliff has been brought from the summit down to the shore, where it forms a promontory obstructing the further progress of the mineralogist, who in defiance of toil and hazard pursues along this rocky coast the beautiful minerals in which it abounds. I have no measure of the heights of these cliffs, but they are considerable. Comparing them with the masts of passing ships I imagine that the highest can not be much less than 800 feet. The cascades which fall over them are often dissipated in spray before they reach the ground, or descend in a mere shower of drizzling rain.

The cliffs continue with more variety of height than of character to Loch Brittle, the habitation of the Osprey, and of, what is more interesting to geologists, some rare minerals which I shall describe in their proper places. At Loch Brittle the land runs out into low projecting points, the interior being of small elevation and disposed in terraces. The cliffs rise but little from this place to the entrance of Loch Scavig, where the coast assumes a new character, the declivities of the hills reaching the sea at a considerable

angle. Here the dark summits of the Cuchullin hills come in view, and new features and new scenes arise to re-excite the interest which so long an extent of an almost uniform character had suffered to languish.

Loch Scavig is an inlet of the sea about a mile in depth, formed by the Cuchullin hills, which rise with all their spiry and naked crags high towering above it. At the bottom of this bay they descend suddenly into the sea, brown and bare, with scarcely a spot of verdure to enliven their dark sides, the only semblance of life they possess consisting in the motion of the few cascades which foam down their rugged declivities. Points of detached rocks projecting into the sea from their base, produce foregrounds for the use of the artist, and relieve that intense depth of shadow which seems ever to reign where the sun beams can scarcely find access. But even the grandeur, the silence and desolation of this place are forgotten, when in a moment on turning the angle of a huge rock, the spectator enters on a scene which suspends the recollection of all which had fascinated him before. He finds himself in a lone valley surrounded by a wall of dark and naked rock, of which the rugged summits are lost in the clouds, intercepting the light of day and casting a twilight gloom over the seat of eternal repose. If ever a sound disturbs this repose it is that of the wind which whistles against the rocks, or of the cascade which rushes down their sides; if ever vestige of life is seen, it is the lone sea-gull dipping its wing in the black still waters of Coruisk.* The valley once closed behind the spectator, he sees no more its egress, and calls to mind the tales of eastern fiction, where the victim of magic

* Coruisk, the water of the mountain hollow, not Coriskin.

is for ever immured in some profound chasm of the mountains of Caucasus. The lake Coruisk is rather more than two miles in length, being fed by a powerful stream at its upper end, and discharging itself into the sea by a wide and rocky channel, a favourite resort of salmon. Its shores are every where covered with huge fragments of rock detached from the mountains above, and it contains two or three small islands which diversify in some measure the darkness of its surface. The nakedness of the rocks is not poetical. On the declivity of the mountain Garsven in particular, they rise from the base to the very summit, a height of at least 3000 feet, in huge smooth sheets at a very high angle, perfectly bare and of a dark iron brown colour, not checquered even by the growth of a single lichen or by one foreign tint to enliven the uniform gloom of the surface. This rock seems indeed absolutely inimical to vegetation, nor does it appear to undergo the slightest decomposition, or to admit of the formation of soil, the detached fragments showing as little tendency to waste as the mountain itself. Had the globe of the earth been entirely formed of this rock it would still have been lifeless and void. It was among these fragments that I observed a rocking stone of considerable size and easily moved, having to all appearance fallen on such an edge as to allow of the conditions required for producing this effect.

In quitting this scene, for which favourable weather is required, since it is inaccessible by land, and the outer loch is subject to dangerous and sudden squalls, little interest occurs on the east side of Strathaird, except one fine example of a slide by which a large mass of the hill has descended to the water.

Having passed the point of Strathaird a succession of cliffs commences which extends nearly to the end of Loch Slapin, formed of

secondary strata, and of an entirely new character. Their upper edge is generally even, and their faces quite perpendicular, but they rarely exceed 60 feet in height. They are most remarkable for the very extraordinary number of the caves which are found in them, and of the fissures by which they are intersected. These are rarely of any great dimensions, but they are so numerous that they sometimes occupy nearly as much space in a given distance as the solid parts of the cliffs themselves. I have counted twenty or thirty of them in the course of a few hundred yards, the interstices having a resemblance to the ends of detached walls placed in a parallel manner. They are the consequences of trap veins which have been washed away, but as they present important geological facts, I shall describe them more particularly hereafter. Few of these caves have been explored, but one of them has acquired historic celebrity from the circumstance of its having been among the numerous places of temporary refuge inhabited by Prince Charles during his concealment. Another has recently become the cause of great resort to Sky on account of its stalactitic concretions, and it is popularly distinguished by the name of the Spar Cave: it lies on the estate of Mr. Macalister, and is too well known to require any more accurate description of its locality. This cave is accessible from the cliffs above, for a short time only at low water, but by means of a boat it may be visited at any time in moderate weather, or with the wind off the shore. The entrance is little less striking than the cave itself, and to the admirer of the picturesque it presents a scene even more attractive. It is formed by a fissure in the cliff, extending for a considerable way and rising into high and parallel walls on each side, its gloom being partially illuminated by reflected light, and its silence scarcely disturbed by the wash of the surf without. A narrow and obstructed opening leads unexpectedly into the cave: hence for a distance of

about an hundred feet all is dark, wet and dreary, till we arrive at a steep acclivity formed of a white stalagmite. Surmounting this with some difficulty, the whole interior and ornamental part of the cave comes into view, covered with stalactites disposed in all the grotesque forms which these incrustations so commonly assume. Lively imaginations may here indulge in the discovery of fanciful resemblances, and the concretions have accordingly received names more descriptive of the fancies of the spectators than of their real forms. The dimensions of the fissure are in this place but inconsiderable, the breadth not being more than ten feet, and the height scarcely exceeding twelve: it is not long however before the height suddenly increases to forty feet or more, and a declivity of perhaps thirty feet in length, from the surface of the stalagmitical and cascade-like mount which forms the division between the sparry and the dark part of the fissure, conducts to a pool of water occupying a space of twelve or fifteen feet in length, dividing the cave into an outer and inner portion. The dimensions are here somewhat enlarged, and the height in particular is much more considerable. At a distance of about fifteen or twenty feet more from this pool of water the stalactitical ornaments cease, and shortly after the cave terminates, the whole length from the entrance to the end being about two hundred and fifty feet. However beautiful the interior of the cave, from the white colour and ornamental effects of the stalactites which incrust it, the want of sufficient dimensions materially lessens the interest, which in all other respects it is calculated to excite. At the termination of the stalactitical ornaments there is a dark descent for a few yards, filled with rubbish, the ruins of the roof above, which being here naked as well as accessible, is plainly seen to be one of the trap veins. This vein is here about ten feet wide, which is the general breadth of the cave itself, and it is easy

to see how by the wearing out of that vein the excavation has been formed, having subsequently acquired its present degree of ornament by the infiltration of carbonat of lime in solution. When we consider the great depth of this cave and its distance at present from the sea, we are inclined to inquire by what means so extensive an excavation could have been formed, and how the rock which has fallen from it has been disposed of. It is probable that the depth of water at the face of the cliffs was once such as to allow of the ready access of the sea to them, and that at this period the excavations so numerous on this shore were produced. The subsequent accumulation of rubbish formed by its action, has in later times produced the slope or shore which now excludes it from further access, and protects the cliffs from further demolition.

In the little excavations which are found in the floor of this cave we have the means of seeing the process by which the formation of calcareous spar takes place, the crystallization being carried on in a solution of the carbonat of lime, precisely as it is in the saline solutions in our laboratories. All these small pools are filled with groups of crystals, in a state of constant augmentation, but of very irregular forms. Doubtless these forms must be affected by the agitation which the falling drops occasion in the solution; and it is in all probability owing to some circumstances of this nature, constant in the same place but varying in different ones, that crystals of one form are found to affect certain places, while in others they regularly assume some other modification. As it offers no novelty to the mineralogist, and belongs to a class of geological facts by no means uncommon, it is unnecessary to enter into any further details respecting it. Such are the principal circumstances which I had an opportunity of remarking, and which appeared most worthy of notice in the general face of the island.

I shall now proceed to consider the nature of the rocks which compose this island, in as regular a detail as my opportunities and its intricate and unsettled geography allowed me to observe and record them.

It was not without repeated efforts and much careful tracing of the successions of the stratified rocks through coasts difficult in themselves and far distant from each other, that I was able to discover the key to the very great obscurity in which these are involved. It will be seen that there are yet points unexplained, particularly respecting the trap rocks, a circumstance which will not surprise geologists who know that to patience, toil, and good seasons, must often be superadded good fortune; the casual discovery of perhaps the only point over a wide tract which is capable of yielding the explanation of which we are in pursuit.

As the mica slate and its associate the quartz rock are the most ancient of those which I have ascertained in Sky, I shall commence from them as the foundation of the whole structure. I have associated these rocks in this manner, because I have generally found them alternating, and bearing a common relation both to those which appear to hold a deeper, and to those which have a more superficial position with regard to them, the granite and the stratified rocks; but I need not repeat these reasons here as I have discussed them at sufficient length in the account which I formerly gave of quartz rock. I have not however traced any decided alternation between these two rocks in this island, nor, as far as I have observed, is it likely that any alternation will easily be traced, since the beds of both are far less regular than is usual when they are associated in an alternating order. The mica slate is found occupying the district of Sleat, and it extends from the point of that promontory to an irregular line drawn between Loch Eishort and Loch

Oransa, the point being much less accurately defined on the eastern than on the western shore. The shores which it forms are generally flat and shelving, but in some particular places, as at Tormore, it rises into high cliffs. The whole tract is however but little interesting, since the uniformity of this rock is only varied by the occasional occurrence of veins of trap and of quartz. If I could determine that the beds of mica slate had a regular position, I would say that they were succeeded by quartz rock, and that this rock terminated near Loch Eishort, being followed by a succession of rocks to be described immediately; but to determine such a succession, a regular disposition is indispensible, since, without that, the uppermost in place may not always be the uppermost in order. I must therefore content myself with remarking that the quartz rock follows the mica slate in geographical position, and that its main body will be seen occupying two hills which lie above Ord, from which the skirts reach to the shores of the southern boundary of Loch Eishort. The mica slate has no peculiarity of structure or of aspect, such as to render a detailed description of it necessary, but I think it proper to remark, that like many other districts of the western isles which contain this rock as the basis of their structure, it is by no means so unmixed as it is generally met with in the extensive tracts of it which occur on the main land. On the contrary, it is frequently found passing into clay slate as well as into talc and chlorite slates, affording an example like Arran, Isla, and Jura, of the intimate geological union which subsists between these several substances. Of the quartz rock I may remark that it is extremely compact, of a highly crystalline aspect in general, and that its weathered surface is so white as to render the hills which are formed of it distinguishable at a great distance by their snowy appearance, while at the same time it is frequently varnished, as it were, with the

same siliceous enamel which is so remarkable at Balahulish. In most situations it contains the common admixture of felspar in grains. Although not, strictly speaking, stratified, it bears the marks of having once been regularly so, the beds having been rendered obscure, partly by the infinite number of cross fractures which it has undergone, and partly by the bendings and displacements which it has experienced. At Ord indeed some extent of it is to be seen lying directly in contact with the beds of red sandstone and in a conformable direction, and here the stratification is sufficiently regular to preclude all doubts, although the beds are not so continuous and unbroken as those of the sandstone.

But I must not quit this district without noticing a remarkable circumstance, uncertain as I yet am whether the observation was correctly made or not. If I have not an opportunity myself to verify or contradict it, I shall at least point it out to those who may follow me through this country.

There is considerable intricacy as well as obscurity in the rocks which I have now described on the western side of the Point of Sleat, although on the eastern there is neither variety nor obscurity to contend with, this intricacy arising partly from the frequent occurrence of insulated portions of the secondary strata skirting the shores, and of which the further details are cut off by the irregular indentation of the sea line. Thus they become in a topographical sense intermingled with the micaceous schist and with the quartz rock in a very irregular manner, while the general confusion is much augmented by the great number and perseverance of the trap veins which traverse them. It is extremely difficult to find a way through this geological labyrinth. It is near Gillan, where among other places this confusion occurs, that the phenomenon in question is to be seen: a bed of highly compact grey limestone contain-

ing shells is here included between two beds of quartz rock; unfortunately but a small quantity of the rock is exposed, and as it lies low on the shore it is impossible to trace the series to the extent which is desirable. As far as I could conjecture the quartz rock was a portion of the general series which alternates with the mica slate: if this be correct it offers a solitary example of a rock containing organized remains alternating with the series of mica slate, a fact as yet so anomalous that it must not be received without much more decided evidence than that which I have here produced. I have to regret that the loss of these specimens prevents me from describing the particular shells which I observed in this limestone; yet doubtful as this fact appears even to myself, it is somewhat countenanced by a circumstance not dissimilar which occurs near Borrereg on the side of Loch Eishort, where the white and crystalline quartz rock which alternates with the mica slate is found in one place alternating for a short space with the blue limestone and red sandstone, the two first and lowest members of the secondary strata. With every wish to find that I had committed an error in this examination I could not detect it, and must therefore suffer the whole to remain at present as I have stated it, an example at least of a most deceptive geological appearance if it shall not turn out to be an interesting fact.

The two associated rocks which I have here described are immediately followed by a regular succession of stratified rocks which I shall now proceed to detail; commencing at Loch Eishort, as being the principal point in which I observed their contact with the former, and from which I derived the clue to the order of succession of all the stratified rocks in Sky.

In distinguishing however the rocks which follow by the term stratified, I am far from meaning to say that I consider the mica

slate and quartz rock as unstratified, but their want of regularity in the present instance, compared with the extreme precision and order of those which follow, render the distinction convenient here for the temporary purpose of describing them. I have in other instances produced sufficient examples of the alternate and regular stratification of quartz rock and mica slate to render it unnecessary to say more on that subject: I have in the same places shown that these rocks alternate with clay slate, and my object at this moment is to distinguish strongly the sudden change from great disturbance to extreme regularity, which takes place here between two rocks which in so many other instances seem to have undergone together the common action of some disturbing force.

The first of these rocks is a compound series of beds consisting of dark blue quartz rock interlaminated with thin layers of clay slate of the same colour: these are to be found in immediate contact with the white quartz rock, and in an order which is conformable to the general position of that substance where it is in contact with them. Often the quartz of this rock prevails to the total exclusion of the schist, and the beds are then much thicker than when the schist interferes. They hold a remarkably even and straight course for a considerable space on the north side of Loch Eishort, dipping to the N.W. at an angle of about 30°. The thickness of this set of beds appears to be extremely variable, but I know not that it can be ascertained, since the excavation which forms Loch Eishort interferes with the observation at the western point of their exposure, as the sea in that place covers the elevated edges, while in their course eastward they become clothed with the covering of soil.

There is consequently a chasm in my attempt to trace their extent eastward, but as the same rock appears on the eastern side with all the same characters, and in the same position with respect

to the mica slate; I imagine no error will be committed if I consider it as a continuation of this series.

This is the rock which forms the high mountains above the Kyle ri'ch, which have already been mentioned in the general description. The principal summits, on account of their elevation, are visible at a considerable distance in coming from Glen Elg, and they occupy the greater portion of that which may be called the eastern promontory of Sky. Ben na Grien and Ben Ashlaig appear to be the highest of the group: these decline into lower elevations, and with some variation both of character and aspect till they disappear, but I have to regret that I can give no account of the connections of either of the outer extremities with the neighbouring rocks. It is too common for the geologist in the course of his labours to find that he has commenced at the wrong end of his investigation, and to discover, when it is too late to profit by it, that he has probably found the solution of his previous difficulties when the difficulties themselves are no longer accessible to him: I can only therefore offer it as a conjecture, that the rock which forms the mountains in question is a continuation of the one already described at Loch Eishort, since its examination unfortunately preceded that of the latter, and it was out of my power to resume it when I had obtained the information which would probably have enabled me to speak decisively concerning it. I would recommend to those who may follow me to trace it with care from Loch Eishort to the eastern shore, by which proceeding they will probably succeed in determining that which I am compelled to leave in doubt, but I may nevertheless describe its leading features. It is by no means regularly stratified, nor is it possible to trace for any considerable distance even the fragments of a regular prolongation of the edges of beds, such as is so distinctly exhibited in the quartz

rock of Jura; yet there are evident marks of stratification, which in many places are sufficiently regular and extensive to justify the belief that it has once possessed a greater degree of regularity and extent, which have been disturbed by subsequent changes. The predominant colour is a bluish or greenish grey, and its most general aspect that of a compact splintery quartz, often obscurely granular, and every where traversed by veins of ordinary white quartz. At Kyleaken it has a brown colour and a fat appearance, but becomes white and harsh on exposure to the weather, in consequence of the decomposition of the felspar which it contains. The great thickness of the mass here, compared with the thinness of the similar rock at Loch Eishort, is no proof of non-identity, since in so many other cases we find strata differing, in perhaps as great a degree, in thickness where we have the most satisfactory evidence of their continuity. I have not observed this rock in any other part of Sky, and it will presently appear that it could not be expected any where but beneath the sandstone near Loch Scavig. I shall not be surprised if it exists at the southern side of Soa under the sandstone beds, since that is its place, but this part of that island was unfortunately the only one which I could not reach. That it is a bed of great extent in this country, although so little visible, is confirmed by its being found in Rum, and in the same position, as I have ascertained.

The rock next in order to this is the red sandstone, and the connection between the two is equally distinct at Loch Eishort, where they are found following each other in a regular order and in intimate contact, there being indeed a gradual passage from the blue quartz rock into the red sandstone by a series of intermediate changes both in point of hardness and colour. The same transition will be found near Kyleaken on the eastern side, although I cannot

point it out so distinctly. The certainty of a transition between these two rocks is equally well marked by another circumstance, although that indication does not appear at Loch Eishort; namely, by the alternation of the beds of schist with the red sandstone, a phenomenon to be observed at Loch Scavig, as I shall presently show. Following this sandstone it is to be seen forming a considerable part of the hills which rise on the northern side of Loch Eishort, and extending along that shore as far as the farm of Borrereg where it ceases. The beds succeed each other with great regularity, and are of considerable thickness; as far as I should judge from a rude estimate formed by comparing the measures of their edges with the space which they occupy, I should imagine that the collective mass does not here fall much short of a thousand feet in thickness, tallying in this respect very nearly with the dimensions which it seems to maintain in Rum as well as in Soa, both of which I have no doubt are different portions of the same rock.

This red sandstone is also found skirting the southern shore of Loch Eishort in different places, and is particularly conspicuous at the castle of Dunscaich, a building of no high antiquity, but situated on a rock, the traditional residence of Cuchullin "King of the Isle of Mist." This position is readily explained by observing that the line of Loch Eishort crosses that of the direction of the sandstone in an oblique manner, leaving thus a portion of it on the southern shore; it is here often in contact with the white quartz rock, the intermediate blue rock having disappeared. From this I should be inclined to suspect that there is a real chasm between the conjoined rocks consisting of mica slate and quartz rock, and the stratified ones now under review, how much soever some of their portions may appear consecutive. I have pointed out at some

length in other places the errors that may arise in these observations, and need not enter largely into the question in this place, but it appears to me a sufficient argument that two sets of rocks are not consecutive if those which correspond in one place do not also correspond throughout. I should expect to find that the same bed of red sandstone exists between Kyleaken and Broadford, where I had no opportunity of looking for it; but beyond that it is not likely to occur, as the limestone which lies at some distance above it in the order of superposition occupies the lowest situation on the shores of Broadford. I mentioned that the same bed is to be found at Loch Scavig, where it is plainly connected with the very large mass of similar sandstone which constitutes the main part if not the whole of the island of Soa; it occupies here the lowest visible situation, being washed by the sea and exposing but an inconsiderable thickness, since it is shortly followed by the trap, when it finally disappears, none of the subsequent stratified rocks which accompany and follow it near Loch Eishort being here found. It is here interstratified with beds of a schist which has sometimes the character of fine clay slate, while at other times, the laminæ being separated by coarser particles of sand and of mica, it puts on the character of that which has been called fine graywackè slate. I have on other occasions shown* that these rocks are not necessarily distinguished in position, and that near Loch Ard in Perthshire, and Crinan in Argyleshire, the several sorts of clay slate and graywackè are irregularly intermixed: the same phenomenon is to be seen in many other parts of Scotland, which I cannot here pretend to enumerate; although the question is of importance to geology, this is not the place in which it must be discussed. The fact abovementioned however extends our objections to the commonly received

arrangement even one step further, since I have shown that perfectly characterized clay slate is here a member (to use the Wernerian language) of the *floetz* rocks; the sandstone here described being analogous to the *old red sandstone* of that school, and a member of a continuous series of stratified rocks, of which the uppermost contain shells and other undoubted characteristics of their rank in the order of rocks.

The extent of this rock on the shore is not great, but it may be seen occupying a continuous line both on the shore of the sound of Soa and within the entrance of Loch Scavig, forming the foot of Garsven, one of the highest of the Cuchullin group.

These are the only places in which I have found this rock, and I have no great reason to expect that it will be found any where else, as its dip does not any where indicate its probable re-appearance; yet I should not be surprised were it to come out at Loch Sligachan, since the limestone which immediately follows it in regular order is to be seen there. These beds, the limestone on the one hand and the quartz with schist on the other, will be guides to those who wish to search for this rock in other parts of the island.

The mineral character of this sandstone is very uniform; it is most commonly of a red colour, but it becomes brown or grayish, when in the neighbourhood of the schist, and sometimes even partakes of the blue colour of this substance. It is of a moderately fine grain and very tractable as a building stone, sometimes possessing the softness of an ordinary sandstone and at others acquiring a flinty kind of hardness, more particularly when it approaches the schist. It is generally mixed with clay, or is of an argillaceous nature, and in some places moreover it is found to contain particles of calcareous matter: in some few places coarser portions are to be

found, formed of large gravel or even of fragments, but I have not seen either in Sky, in Soa, or in Rum, any regular beds of conglomerate connected with it, although I have in these situations had repeated access to the whole thickness of the rock. Although the general colours of this rock are such as I have described, yet it seems occasionally, like the lowermost red sandstone in other places, to contain portions of a different complexion; one portion of such a bed is seen under Garsven opposite to Soa, where it is of a white colour and intermixed with decomposed felspar, yet still exceedingly compact. Pebbles of quartz and granite are imbedded in some of its laminæ. For the sake of those who contend for the doctrine of universal *formations* of rock, I have recorded the whole of its characters and connections that they may have opportunities of comparing them with those of other similar rocks, and I can only add to what I have here said, that as I imagine Rum and Sky to contain portions of one common bed, so I am inclined to think that the red sandstone which I have found on the western coast of Scotland in various places, from Loch Ewe to the Ru Storr, appertains to the same series of beds. It is still the same sandstone, as I imagine, which extends to the east coast and finally to Orkney.

The next bed in order is a bed of limestone, the investigation of which was attended with more labour and doubt than that of all the other rocks of Sky, and of which the history I am about to give cannot appear less credible to others than it did at first to myself: the demonstration which I at length procured and shall now lay down is however such as to admit of no dispute. It is important in a general view since it shows us how little reliance can be placed on internal characters in assigning the positions of rocks in the system, and since it may possibly lead the way to the explanation of those anomalous limestones to which the examples occurring near Ply-

mouth, and as yet involved in so much obscurity, may perhaps belong, and which have been ranked in the class called *transition* by the Germans, since they were supposed to be of higher antiquity than the secondary or *floetz* strata of the same school. This bed is found at Loch Eishort immediately following the sandstone, with a common dip, and in every respect perfectly conformable to it. It is readily distinguished wherever it occurs, provided its upper surface be exposed to the weather, and this at very considerable distances, the appearance which it here puts on being that of detached and irregular masses with a deeply honey-combed surface, the cavities being from a foot to two in depth, rounded and perpendicular, while the projecting portions are equally rounded and smooth. No lichen attaches itself to that surface, but whatever its hue be, it weathers to a bluish colour, by which it is visible among all the surrounding rocks. I could find no means of ascertaining its thickness at Loch Eishort, but near Kilbride where it is fairly exposed it is some hundreds of feet thick; I have however reason to imagine that this dimension is very variable. It may be traced where it first appears at Loch Eishort from the point where it is in contact with the sandstone, for a considerable way up the hills in the direction of Broadford, but is at length lost amidst trap and syenite, and amongst the mossy and deep soil of this rough ground. Pursuing the line of shore it shortly disappears, other beds coming in the way which will follow next in the order of description; but it is recovered at Kilbride, and hence may be traced through the remainder of its connections to the no small surprise of the geologist. As the sandstone bed does not exist at Kilbride the identity of the limestone cannot here be proved by that of the beds on which it reposes; instead of sandstone indeed its lower surface is found in contact with the syenite already generally

described. The absolute identity of its aspect, composition, and mode of weathering, might perhaps be sufficient to prove the identity of its nature, but this is put out of all doubt by finding that it is here followed by the same set of beds which succeed to it in that place where the sandstone precedes it, and of which the continuity can be traced between the two points. The drawings (Pl. 2. fig. 1.) which accompany this paper, will explain better than words this very essential circumstance in the geological history of Sky.

There is here an opportunity of tracing by a very perfect natural section the change which it undergoes between the very regular beds which lie near it on the one hand and the irregular surface of syenite with which it is in contact on the other. At this surface it bears no marks of stratification, but is an irregular and almost shapeless mass, while near the former beds, which also consist of limestone, it becomes first vertical and gradually more regular, till at the end its general bearing, although much deformed by counter fissures, partakes most decidedly of the general inclination of the stratified rock, which is here about 25°. In geographical distribution it may be here traced in two divisions, separated from each other by syenite and intersected by trap veins, both of these divisions extending towards Broadford and uniting into one scattered and irregular mass about three or four miles short of that place. The uniformity of its character, as well as its continuity throughout this tract, is such as to leave no doubt that the marble of Broadford already mentioned, and which I shall hereafter more fully describe when I speak of individual minerals, is a continuation of this portion of the limestone beds. When it has once quitted the sandstone that rock is no longer seen, but the whole remaining portions of the limestone, occupying a great space from the hills which skirt the eastern side of Strath to the foot of the syenite mountains on the opposite side, is

(always with the exception of whin dykes) in contact with syenite; this contact can be distinguished in many places at the surface, and it has moreover been brought to light in the excavations which have been formed at the marble quarries; it is so intricate that the limestone is often divided into insulated portions surrounded by syenite, and were it not for the clue which is given by the shores at Kilbride the whole tract is so obscure that it would have remained as unintelligible to me now as it did in the first examination which I made of it. It is too speculative an inquiry to consider what influence the syenite may have had in producing this irregularity; nay I have not even the means of proving that the syenite is posterior to the stratified rocks; but in the course of examining that rock hereafter, I shall assign reasons for supposing that this is really the case, and that like the trap rocks to which it is associated it is not improbably the cause of all the irregularity apparent in this place.

If even the shadow of a doubt could remain respecting the connection of this, which I shall distinguish by the name of the marble limestone, with the shell limestone, it is removed by the discovery of a regular alternation of the two near the farm of Borrereg, a sketch of which (Pl. 2. fig. 2.) is introduced into one of the sections designed for the illustration of these rocks.

The limestone having completely lost all semblance of stratification where it is involved among the syenite, is found forming large insulated lumps, of which the great structure and general fracture resemble that of the Devonshire insulated limestones, and those of Assynt which I have described in the Geological Transactions, vol. 2. It is fissured in various directions, and can be raised in large irregular blocks only. Hence it has very naturally been considered as a primary limestone, an error into which I was at first inclined to

fall myself. This is confirmed by its texture as well as its colour, both of them resembling those which are supposed to be characteristic of primary limestones. In these respects indeed it possesses an exact resemblance to the limestones which we find in various parts of Scotland associated with schist, gneiss, and granite, of which I have recorded examples in different places. From this, as I have already hinted, we ought to receive with distrust any attempt to distinguish the primary and secondary limestones by internal characters, nay even by their external forms, since in this respect also the limestone of Strath bears a perfect resemblance to the primitive limestones already alluded to. The texture of this stone is almost every where compact, with a fracture finely granular in the surface, and varying between the splintery and conchoidal. It is generally brittle, a character rare in the stratified limestones, and in many places even breaks with the violence and cleanness of siliceous schist. In its chemical composition it is generally pure; but where in contact with the syenite or the trap veins, becomes overloaded not only with silica but with magnesia and argil also. In such situations it often contains veins and nodules of greenish transparent serpentine, and adopts a variety of colours, a circumstance in which it also resembles most exactly those limestones which in Glen Tilt are found in contact with granite, or at Balahulish, and in Tirey and Iona with mica slate and gneiss. The predominant colour is grey, varying from nearly white through all shades of dove colour to a dark blue grey, sometimes beautifully striped, and mottled or veined; in many situations it is of a pure snow white, forming a perfect variety of statuary marble, which I shall have occasion to describe more particularly hereafter, and affording as yet perhaps a solitary instance of this variety of limestone occurring among secondary strata. When I say a solitary instance, I

must however add my suspicions, that when more attention shall have been paid to geological investigations, many of the facts which I have enumerated in various parts of these papers will not appear either so solitary or so extraordinary as they now seem.

I have shown that this limestone is in contact with the syenite, and it is also in contact with trap, since a hill of this substance is found surmounting as well as interfering with it near Loch Eishort. I might therefore proceed to describe these rocks according to the order which I have adopted; but nothing certain is as yet known of their real places, and if, as I imagine, and as I think will appear not only here but on almost every occasion where I have described them, they intrude among the regularly stratified rocks, it will be better to defer the consideration of them, as I have done on other occasions, to the last. Before however finally quitting this limestone I must not omit to mention that a similar one is found occupying the south side of Loch Sligachan in a similar manner, and that it has in all probability the same origin and connections, although I had no opportunity of investigating it to my satisfaction.

Returning to the original point at Loch Eishort we find the series of beds which follows this limestone in contact with it. At the very point of contact there is an interference of the two sets, which is highly satisfactory, as tending to establish their perfectly consecutive nature, and consequently of determining the place of the former limestone without the shadow of a doubt. Where they meet, two or three laminæ of the uppermost limestone alternate with an equal number of the lower one, and they are readily distinguished, because the upper ones being mixed with schist have a superior degree of permanence, and project with a sharp edge on the vertically corroded sides of the subjacent one. The upper limestone is equally to be seen following the under one at Kilbride;

but the same interference is not visible there, although the parallelism is perfect.

From either end of this junction the limestone beds of the upper series may be traced all round the point which separates Loch Eishort from Loch Slapin, intersected every where like the former by trap veins. Neither the thickness, the number, nor the order of these beds can be ascertained, as they are much too complicated and difficult of access to admit of such an examination. The very attempt would be a superfluous endeavour after accuracy, since enough of them is ascertained to prove that only which is important to be known, the order of their connections with the neighbouring rocks, and the characters by which they can be identified with more distant strata. In general they are formed of thin and thick laminæ, composed of a dark blue earthy limestone, at times somewhat more crystalline, and variously interleaved with argillaceous schist of various dimensions. These beds, like the former, are inclined at an angle of about 25°; they seem most regular as well as thickest at the point of separation between the two Lochs Eynort and Slapin, while near the very same place they are also found in very thin schistose laminæ, so that I imagine there is no rule to be laid down respecting them; they are found occupying the island of Heast, as well as a long ridge of rocks which here intersect Loch Eishort; and they may also be traced at Ord, and further down this shore even as far as Gillan, following the red sandstone, for the same geographical reasons, probably, that I assigned when speaking of that substance. Here however the intermediate bed, that which contains the marble, is deficient, and we have already seen that the blue quartz and schist are also deficient, so that the order is here mica slate, red sandstone, schistose limestone; instead of mica slate, blue schist with quartz, red

sandstone, marble limestone, schistous limestone, two important members having disappeared in so short a space. This is the only instance which has occurred to me in Sky of discontinuous strata, since the Western Islands exhibit but few examples of this class of rocks, and I am glad to have an opportunity of mentioning it, as I am convinced that such discontinuities are common in nature, and that great errors have been the result of the fondness with which geologists have pursued through viewless regions of the earth, continuities of strata, and universal formations. But to return to the upper limestone. It is often remarkable for the cavernous and corroded aspect which it assumes where in contact with the sea, which arises from the falling out of the shells which it contains. The beds are numerous but irregular, and the shells themselves vary much in quantity in different places. I could find only three species, a gryphite, an ammonite, and a cardium, nor do I know whether more are contained in them, since but few of the numerous beds are accessible.

It is now necessary to attempt the tracing of this bed in other parts of Sky, and I imagine that this can be done to a certain extent. This examination might have been rendered more complete by myself had I commenced the survey of the island in the reverse order to that in which I have described it, being guided for want of a better reason by mere geographical convenience. Hence the remarks on the distant and solitary fragments of strata, made when there was no prospect of connecting them, are less perfect than they would have been, had I commenced the survey where I have now commenced the description, and they are insufficient for assigning their general connection. Since however the strata of limestone found at Broadford contain the same animal remains, I have no doubt that they are portions of the same strata, and that

the beds of this substance, which are visible along various points of this shore as far as Sligachan, are equally continuations of the shell limestone, more particularly as the marble limestone is also found at Sligachan in that position in which it might be expected with respect to the former. But I can give no clue to the history of the limestone which is entangled among the trap to the north of Broadford, having neglected to make such an examination of it as would have been required for this purpose. I must trust to some future geologist for the completion of what I have left unfinished. The most remarkable of these unascertained beds is found to the north of Portree, far inland, and extending towards the Storr on the eastern declivity of that range of hills, being interposed among enormous beds of trap. Others may be seen in various positions accompanying the secondary strata which lie under the trap on the shores of Trotternish; but as I can not pretend to give such a geological description of them as would satisfy myself, I must be contented with this cursory indication of their localities. I have little doubt that with the clue which I have now furnished, the task of assigning their geological relations will be found easy.

I find some difficulty in continuing the pursuit of the stratified rocks upwards from Loch Eishort, because a great geographical chasm now takes place between those already described, and the next most extensive mass which forms the promontory of Strathaird, and because they are connected but by a small indication of their order of succession. In the general description I have noticed that the rocks of Strathaird consisted chiefly of sandstone, alternating with thin and rare beds of limestone: these I conceive to be the next in order of superposition, and the proof rests on this. At the point which separates Loch Slapin from Loch Eishort a series of sandstone beds is found following the limestone lately

described, and evidently in a higher situation: it is a calcareous sandstone, and bears a precise resemblance to that which constitutes the whole of the eastern side of Strathaird. Now as no sandstone of this description is found among the lower beds, and as we have clearly traced the order of those from the mica slate to this point, I think that we need not hesitate in placing the sandstone of Strathaird in the situation which I claim for it, the last in the series of the secondary strata. However that shall be determined, I must proceed to describe it. It is to be seen reaching from the termination of the trap on the western side of the promontory, round the point of Aird to nearly the upper end of Loch Slapin, preserving a great evenness of direction and consistency of character throughout this space. I have called it in general a sandstone, although it will be seen that it also contains beds of limestone, but in small number and quantity. The position of the leading line of these beds is so generally horizontal that it is never found to vary five degrees, and that variation is so gradual that it will often pass without notice: but it is attended with a disposition so remarkable, that I think it necessary to point it out, and as it is difficult to render it intelligible in words, I have added a diagram* for illustration. Each bed seems compounded of two parts, the one a single horizontal lamina, and the other a series of inclined ones, or, there is a regular alternation of a set of inclined laminæ with one horizontal one. These are perfectly defined, since the intervals are deeply channelled by the weather, the whole having the aspect of some of the carved ornaments of Saxon architecture. This appearance gives on a first view the impression as of a regular series of beds, alternating with each other, of which the one is horizontal, and

* Pl. 4. fig. 1.

the remainder in an unconformable position to it. But it must rather be considered as the indication of an internal structure, of which however all marks disappear when a fracture is made, a case analogous to what occurs in basalt and many other rocks, of which the internal structure is so often detected by the changes which they undergo on exposure to the weather. A similar case, which I have observed in the argillaceous schist of Isla, serves to confirm this explanation. The appearance in this instance is so precisely like, that the same drawing will serve to represent both, and the nature of the cause is amply confirmed in this, that while the beds of the schist are apparently divided in the direction marked by the horizontal lines, they are fissile only in that which is marked by the oblique ones. It hence also follows, that if the fissile property of clay slate is the result of some internal arrangement analogous to crystallization, we are equally entitled to attribute the structure of this sandstone to the same cause. The inclination of the oblique laminæ upon the horizontal ones varies from ten to thirty degrees; but it is regularly in the same direction, the dip, if it may be so called, being to the south. This appearance is neither rare nor dubious, it is extremely well marked, and predominates throughout the whole range. The measurement of the parts having been mislaid, I speak from recollection when I say that the intervals between the horizontal lines vary from one foot to a foot and a half. There is no difference in the quality of the two sets of laminæ, both are of white sandstone, generally more or less calcareous.

To enter more minutely into the composition of these beds, let me now remark that the sandstone often acquires the aspect of some of the most compact and crystalline varieties of quartz rock, while in other cases it has the lax texture of an ordinary freestone. In some places it is calcareous, and the calcareous matter varies so

much in quantity that the compound would sometimes be called a calcareous sandstone, while at others it would be described as a siliceous limestone. In the latter cases it is often dark-brown, gray, or even of a dark lead blue. The beds of mere limestone are rare, and those which I observed lie towards its upper boundary; they are of considerable size immediately in the vicinity of the Spar cave, which I described at the commencement of this paper. I think they are much more generally granular than compact, and some of them indeed resemble an aggregate of rounded grains, of the size of mustard seeds, not much differing from some of the oolites, but more compacted, and generally containing, besides these grains, crystallized platy particles. These strata are intersected in a remarkable manner by trap veins; but I shall defer the consideration of those to that which I conceive their proper place, the last in the history of the rocks.

The geographical chasm which intervenes between this and the remaining portions of white sandstone found in Sky is such, the want of accompanying strata so general, and the absence of characteristic indications in the internal composition so great, that I feel quite unable to determine the nature and connections of these detached portions. If any thing can be drawn from such indications as they present, they seem rather to prove that the sandstones which are found at Portree and in the northern parts of the island, appertain to strata different from those last described; but the remarks I have already made on the discontinuity of the limestone and the blue quartz rock, render me diffident in admitting any evidence respecting continuity of stratification, or the reverse, without access to proofs of a more decided nature.

White sandstone is to be found in many places on the eastern coast of the island, and is readily visible at Portree, where it alter-

nates with the trap in the same manner as it does in Egg; and in this neighbourhood it also exhibits the same appearance of globular concretions which occur in that little island. It also is found in several places, containing globular masses and fragments of trap, such as are frequent in the similar sandstones, which are seen on the opposite coast of Raasa. The same appearances continue along the shore to Camiskanevig; and although I did not approach the land sufficiently near to be certain of the fact, I am inclined to think that similar arrangements exist all the way to the Altavig islands. Sandstone is found moreover on the eastern side of Loch Snizort; and, I may add, generally on the western shore of Trotternish, particularly at Duntulm, where it contains shells, of which, for the reason mentioned in speaking of the limestone, I neglected to take a sufficient note, not being aware that they might be of future importance in my researches. Here however it alternates with shale; and, unless I am mistaken, with very thin laminæ of coal, such as occur in the sandstone of Egg, while it also contains imbedded fragments of charcoal, and I am therefore inclined to think on these indications, that this sandstone belongs to a deposit still susuperior to that of Strathaird, and probably the same as that which is found in Egg. The last white sandstone which I met with was in Glamich, where it was penetrated by veins of trap and mingled with the mass of the hill, but the space I saw exposed was so very small that no conclusions could be drawn from it.

I must not terminate the description of these strata without pointing out a circumstance of importance which might otherwise escape the reader's attention, namely, the conformity of all these rocks. I will omit that conformity which in some places appears to exist between the mica slate and quartz rock, and the incumbent ones, because it is certainly incomplete; but between the bed which consists of blue quartz rock and slate, and the red sandstone, it is

complete, and consequently the same for the whole way upwards. Now in our system of geology, not only is this sandstone considered the first of the secondary strata, but the schistose rock is ranked among the primary or among the *transition;* and the difficulty will be equal which ever term we adopt. If the nature of the sandstone did not determine its rank, its place after the schistose rock would be sufficient for that purpose: so that here the primary and secondary strata are not only following in conformable order, but that order is demonstrably not accidental as in Mull, where an instance of this nature occurs, since there is a perfect interference and alternation of the two at the point of contact. Those rules therefore, which would define the secondary rocks by their want of conformity to the primary, either have not selected the first of these primary rocks as their basis, or, the law of non-conformity and of a thorough separation between the two classes is exceptionable.

Having thus as far as is in my power described, according to their superposition, the rocks which seem to follow in the most regular order, I shall proceed to describe those which are uppermost, the trap and syenite, which will complete the account of the rocks of this island. In naming these as uppermost, I am far from meaning to say that they are exclusively so, as I shall on the contrary show that they also penetrate the superior strata. No distinct position can in fact be assigned to rocks which are not stratified, and such are generally granite and trap. These unstratified substances interfere with almost all the regularly placed rocks. Although granite is not indeed found passing through or lying near the primary stratified rocks, unless in the form of veins, yet it bears no regular relation to them, and is occasionally found in the same place, in contact with every individual of a series of different stratified substances. The other unstratified rocks, trap and syenite, bear a still more intricate relation

to those with which they are connected, since they interfere not only with the primary ones, but with almost the latest of the secondary, and are frequently found lying indifferently both above and below these latter. Hence have arisen distinctions which are often merely nominal, and founded on false theoretic views, of traps of one or other age, of first, second, third, and newest formations. The same identical mass will often possess the characters of all these, since it will in one place be found incumbent on the latest, in another on the most ancient rocks. Except this, I know not that any certain marks of distinction can be pointed out among the several traps. In the greater number of instances at least which have fallen under my examination, such a relation between an unstratified rock, occupying the irregular and uncertain position which trap does, and those regularly stratified ones which maintain a constant order of succession, is by no means a criterion by which to judge of its relative order with regard to these. The aid of a diagram is perhaps required to render this statement intelligible to those who have not examined the rocks for themselves.* The same mass of trap will be found in one place incumbent on clay slate, in another on red sandstone, in a third on shelly limestone, in a fourth on the uppermost secondary strata. In such a case when the separate portions are either not all accessible, or when they lie far distant and interruptedly, we might be easily led to conclude that they were so many distinct deposits, and thus apply to them terms derived from the particular beds with which they were found immediately in contact. A more intimate acquaintance with them, and with the general nature of trap is required to correct these erroneous conclusions, and the accompanying* sketch, will explain that which actually occurs in nature, and of which, if I mistake not, instances are

* See Pl. 4. figs. 2 & 3.

to be found in the very island of which I am writing, as well as in many other situations in Scotland. I do not however mean to deny that instances exist where a real distinction of periods in trap rocks can be proved, and I have myself observed some which I shall perhaps have occasion to describe at a future opportunity. I am only desirous to enforce on geologists the necessity of drawing their distinctions from real and not from theoretical views, and of establishing criteria which are better founded, and which rest on more satisfactory evidence than that produced by the mere apparent or even real superposition of an unstratified above a stratified rock. I am even inclined to think that at least two very distinct formations of trap are to be found in the western islands of Scotland, but I cannot discuss the proofs in this place, as the island of Sky has not as yet produced sufficient evidence of them to satisfy me.

Amid the doubts which prevail in the minds of others, the prejudices derived from early habitude with erroneous systems, the natural obscurity of the subject itself, and the extremely inaccessible nature of these rocks, I find it difficult to preserve a consistency in the account which I shall give of them, and to render the details of the history of this family of rocks so distinct, as I am confident it will hereafter turn out to be when the subject becomes better known, and when nature shall have been examined by a greater succession of real observers, who, however desirous of supporting systems, are still more anxious for truth.

In commencing the account of these rocks the trap* and the

* I think it necessary to say that I have throughout used the term *Trap* as the name of a family, including basalt, greenstone, tuff, amygdaloid, trap porphyry, and many other varieties of rock which have as yet obtained no names, and which constitute a class equally distinguished by their geological as by their mineral characters. I have preferred it because as it is derived from the external outline so common and characteristic of this

syenite, I must premise that I have not found in Sky any indication to denote the relative order of the two. If indeed they are both irregular substances, as I think there is no reason to doubt, any priority or posteriority is out of the question, or at least it cannot be ascertained by examining their juxtapositions. If the one set were proved to be constantly superior to one set of stratified rocks, and the other to a different and later set, the question of rank might be settled between them: but these connections are difficult to ascertain to a sufficient extent, and possibly none such exist. If one stratified rock is in one place superior to another, we are sure that it is every where superior; but if we have ever so clearly proved that a body of trap or of any other unstratified rock is superior and in contact in one place to any given stratum, we have no certainty that it is equally so every where. Thus I shall in this island show that the trap rests in one place on the latest sandstone, in another on the earliest. No means therefore are offered here of determining the relative order of these two unstratified rocks, but I have little doubt from the phenomena which I have witnessed in Rum and Mull, that they are both portions of one irregular mass. I shall therefore commence with the trap as the most extensive.

I was once inclined to make a distinction between the trap which forms so large a part of the Cuchullin hills, and that which is found

class of rocks, it is in no danger of misleading by producing any confusion of individuals, and because it was already in use as the name of many in this family without having been rigidly limited to any one species. I have also chosen the term syenite as the generic term of a set of rocks generally allied to these, and which had already been applied to that rock by Werner, excluding from this denomination the original and *classical* syenite, which, as well in geological connection as in mineral character is a mere modification of granite. The compound term syenitic granite may be applied to this, as I have remarked in a former paper. Varieties intermediate between common trap and syenite may be called syenitic trap.

occupying the great mass of the island, from the difference of their external characters and form, and from the existence of some particular varieties in the one, which are not found in the other: but I have not the means of drawing this distinction, nor of saying where or how they are connected or disjoined. I have little doubt that there are distinct deposits of trap rock of different periods, as well as that there are veins of the same; but whether these two leading divisions in the external appearance of Sky are also distinctions in the geological æra of the rocks which form them, is more than I can determine, since they have no distinct set of connections by which such a supposition could be verified. Further, when I attempt to trace their connection with each other, I imagine that I can every where see the mountain trap of the Cuchullin, blending with the stratified trap of the coast; and this opinion is confirmed by every thing which I have observed in Mull, where every possible variety of this rock from Gribon to Ben More, and thence to Loch Don on one hand, and Mornish on the other, appear to succeed each other without discontinuity or interruption, and with changes of character so gradual, that no line of interruption can any where be found. As however I consider this to be an object of the first importance in the history of this rock, I shall still suspend my judgment, pointing it out to other geologists as a subject highly worthy of investigation.

As I consider the term *floetz* to be in this case improper, since it implies the hypothesis from which it is borrowed, I have distinguished that trap which is placed in a horizontal form, and of which the terraced edges are so very characteristic, by the name of stratified trap, using the term beds or strata indifferently, and without meaning by the use of either to insinuate any thingres pecting

the mode of its formation. The other I have called mountain trap.

The terraced trap forms by far the greater portion of the surface of Sky; but as it is sufficiently defined in the map and in the general description, I will forbear here to name its boundaries. Its northern and principal tract is every where continuous, but at the southern side of the island there are detached portions, which I shall first notice. The southernmost in position is a hill of no great extent, which is seen above the secondary strata already described at Swenish point, between Loch Slapin and Loch Eishort. This mass is connected with two large bodies like roots, (inasmuch as they have neither the parallelism nor the independence of trap veins) which cut through the whole mass of strata, and disappear below the sea. I consider this place as of great importance in the history of trap, as it shows plainly how a particular mass of that rock may appear fairly incumbent on a given stratum, while it is in fact connected with a much deeper set of rocks.

It is plain that partial views of this mass at any one point of all the various substances which it traverses, would assign to the same rock all the several hypothetical characters according to which trap has sometimes been divided. It would be called in one place primitive, in another transition, in a third flœtz, and so forth. As I do not intend to enter into the well-known questions respecting the origin of trap, I forbear to point out how this appearance bears on any of the hypotheses which regard its formation.

The next of the stratified masses of trap which are seen toward the south are the hills which decline from Blaven to Strathaird, and appear to be similarly incumbent on the stratified rocks of that promontory, but I had no success in my attempts to discover their

junctions. These are the only detached masses, the remainder of the stratified trap forming one continuous mass, occupying the limits already referred to. It would be an endless toil to follow the varieties of this rock in the narrative as I did in the examination, as fatiguing to the reader as the writer, and equally useless either in a topographical or geological view. After describing such of its connections with the secondary strata as can be discovered, I shall content myself with enumerating a few of the most leading varieties, particularly such as add any illustration to the history of the rock, and with describing the localities of the most remarkable strata.

The contact of the stratified trap with the secondary rocks is seen very frequently on the eastern coast, as well as on the western shore of Loch Snizort, but it never occurs between Dunvegan head and Soa. In speaking of the secondary strata, I have already mentioned the most remarkable points where these contacts are visible, and need not therefore repeat them: they are most accessible in the neighbourhood of Duntulm, and from Portree northwards the alternations can be readily traced. I observed nothing so particular at the junctions in any place as to require a detailed description, except the contact of the basalt at Duntulm Castle, with the siliceous schistus, which I shall describe hereafter.

Among the numerous species of the trap family here existing, basalt is the most conspicuous, and it occurs almost every where, alternating in an irregular manner with all the other species or varieties. It is most frequently amorphous, displaying at the same time so great a variety both in its natural mode of breaking, in its external appearance on weathering, and in its texture and colour, as to form a great number of subordinate varieties much more remarkable in their natural situations than when broken into hand specimens. At Talisker it is found perfectly black, and of an ex-

quisitely fine grain, as also in other situations both on the western and eastern shores. Considering the great extent of this rock it is but rarely columnar. The most beautiful and conspicuous collection of this nature is found at Little Brichel near Talisker, and ranges of tolerably defined pillars are also to be seen in many places of this neighbourhood occupying elevated situations in the cliffs. Columns of considerable regularity are also found at Floddigary near the north end of the island, and immense and continuous ranges of a kind imperfectly defined occur in the vicinity of Duntulm.

The next of the most conspicuous varieties of trap in Sky is amygdaloidal. I should perhaps in strictness rather have defined this rock by its base than by its structure or accidents, but mineralogical language has no means of distinguishing, not only the infinite variety, but the perpetual variation of the bases which are seen charged with these nodules of occasional minerals. It is sufficient to say, that in hardness the base varies from basalt to almost the softness of dry clay, and that the colours are black, bluish, brown, dark purple, and gray of different tints, sometimes of a very pale tone. As these varieties often occupy different strata, and are variously intermixed with the solid kinds already described, the strata, when viewed in the cliffs, often seem to possess a variety of composition which when examined into proves fallacious. The nodules imbedded in these amygdaloids are very various, few of all the substances usually met with in the trap rocks being wanting in some part or other of Sky. The zeolites are the most conspicuous, since all the varieties but one, the ichthyopthalmite, is found occupying their cavities, and often in forms so large as to require a separate consideration in the subsequent part of this paper.

Calcareous spar, chlorite, steatite, quartz, chert, chalcedony, and prehnite, occur in other varieties; among which the two latter are

most rare, and on no occasion have I seen barytes, a substance not uncommon in the trap amygdaloids of other places. At Talisker, mica is to be observed in some varieties, a substance among the least common; and in the vicinity of Scavig, epidote is an ingredient, the rock resembling precisely the specimens found in Caer Caradoc. I have never met with olivin in these traps.

Various complexions of greenstone are found among the strata in different parts of the island; but they are far less common than the basaltic varieties. In one instance I observed specimens in which the crystallization of the hornblende was very perfect. The porphyries of this kind occur also in different places, but like the greenstones they are much inferior in quantity to the uniformly basaltic kinds. The felspar is sometimes glassy, sometimes opake, and the compound at times forms beautiful specimens. I did not observe among the stratified trap any example of clinkstone; and wacke is I believe totally unknown in this island, although some of the more earthy amygdaloids have been improperly designated by this term.

The substance known by the name of trap tuff, and which I have for reasons elsewhere assigned called trap conglomerate, is the last which I shall enumerate of the varieties which come under the general denomination of trap, and indeed no more can be enumerated, since the terms applied to the several members of this family are exhausted. This also occurs every where, and (as is I believe very common) every where irregularly intermixed with the other varieties. I saw no example however of that variety containing rounded nodules and foreign substances which occurs in Canna, the conglomerate in Sky always appearing to form a loose mass of angular fragments of gravel and sand easily mouldering to dust and soil.

It is now necessary to describe some substances which although not appertaining to this family are often found united with it, and

some of them rarely, if ever, any where else. They were too small in quantity, and too little connected to admit of a place among the stratified rocks. These are iron-clay, coal, siliceous schist, and a particular sort of jasper. They occur separately or together in different places, but the whole are very conspicuous at Talisker. They are all extremely irregular in their positions, and discontinuous in their lateral extent. The iron clay is the most abundant of these, and forms considerable beds in the cliffs about Talisker, and along that coast as far as Loch Brittle. It is of various colours, red, purple, blue, and gray, and these are often very lively, giving to the cliffs the appearance of having undergone the process of calcination. The coal is rare, but occurs in different places, and its character in such situations is so well known that it is unnecessary to describe it. The siliceous schist is not abundant, but it is found in its most ordinary form, and also in that very remarkable concretionary globular shape, which having described at full length in speaking of the Shiant Islands I need not repeat here. The jasper is rare. I have used this term because I know of no other by which it can so well be characterized. It is yellow or brown, with a lustre approaching to resinous, and is well known as a product of the volcanic island St. Helena. The specimens of Sky differ in no respect from those of this island, which have sometimes, but improperly, been called pitch stones. That they are not such, if proof were necessary, would be sufficiently proved here by the regular gradation which they undergo into clay, appearing indeed to be portions of clay which have undergone changes in consequence of their vicinity to the basalt, resembling the well known ones which sandstones experience in similar situations*. The succession of these several sub-

* I have since received similar specimens from Guadaloupe, where they occur among the lavas of that island, adding one more to the numerous analogies already existing between the volcanic rocks and the trap family.

stances is often found in the same place, but their order can never be ascertained, for, the cliffs rising to a height of 500 feet or more, they are so far out of reach as to prevent us from forming an accurate judgment respecting the individual parts. It is only by examining the fallen specimens that we can ascertain the number of the varieties in any spot. They seem to me greater from Loch Bracadale to Loch Brittle than elsewhere, but possibly this opinion may only have arisen from the greater facility which I experienced in examining this line of the coast. I have in several places attempted to count the number of strata, and they seem to vary from eight or nine to twelve, fifteen, or even more, but it is not easy to define their boundaries at the distance from which they must be viewed. The way in which the several beds decompose often adds a very remarkable feature to the cliffs: some become scoriform, others moulder into large cavernous shapes, while a third set fall to powder; and these various appearances, combined with the colours of the iron clay, give to the whole that aspect of having undergone the action of fire, which strikes a common observer even more forcibly than a geological one.

I must now proceed to describe the trap which forms the mountains, and which is not entirely limited to the Cuchullin hills, since it is found constituting a great portion of Blaven, as well as parts of the hill of Glamich, and of others whose names cannot be ascertained, but of which the predominant parts are syenite and clinkstone. I have no means of defining their limits with greater accuracy, partly because there is no sufficient map, and partly because the country is nearly impassable in many places, and in others quite inaccessible.

I have attempted to trace at the foot of Garsven, the southernmost of the Cuchullin, the point where the stratified trap ceases and

the mountain trap commences, because there only are they seen on the shore. Hitherto I have had no success, although there is a decided difference between the disposition of the two if distant points are assumed. I should have been convinced that such a distinction was to be found though I had failed in finding it, had I not been equally unsuccessful in determining the transition of the two in Mull. Yet I am still inclined to suspect the accuracy of my own observations, and I must leave it therefore as a point to be ascertained by those who shall think fit to follow me.

The junction of the mountain trap with the stratified rocks is very visible for a considerable space between Soa and Loch Scavig. It is here found in contact with the red sandstone, which I have fully described in its proper place. No appearance of the upper strata is here to be seen, the whole body of the mountain following upwards immediately after the sandstone. I know not that any thing worthy of notice exists at the junction. All the strata, both of schist and sandstone, are here as equal and straight as elsewhere, or if they are disturbed it is by the trap veins which are independent of the mountain. Nor are these rocks marked by any particular induration or affection of their composition. Yet I may remark that their angular elevation is less regular than at Loch Eishort, and that they are frequently inclined at much higher angles with the horizon than in this latter place.

It will be readily apprehended from the remarks which have been made in the geographical description of Sky, that the peculiarities in the outlines and appearance of the mountains arise from the mode in which the rocks that constitute them are disposed, and from the forms which these assume during the progress of disintegration. In describing the forms of these rocks I can only pretend to detail the

characters of the southern part of the group, Garsven and Blaven, since I was unable to procure access to the other portions of it.

In other parts of Sky we have seen that the greenstones as well as the other varieties of trap, are disposed in a flat or apparently stratified manner by which the general aspect and outline of all these portions of the island are determined. Here on the contrary the external outline and general features are those of granite, and I may say that to its forms they appear also to add its permanence and durability. They are disposed in huge curved beds of which the external angles are, like those of granite in similar cases, slightly rounded, and they extend over considerable spaces, offering smooth sheets of rock unmarked by a single fissure or indication of past or future fractures. No eye could distinguish them from granite except by examining their composition. Their resemblance to this rock in disposition, and their dissimilarity to the greenstones of the stratified parts of the island, are in every way so decided that no position can be assumed, nor any view taken of them, however general, or on a scale however comprehensive, which can convey the slightest idea of a tendency to stratification. Nor do they in any case that I have seen shew the tendency to vertical fracture so common among greenstones, being in every respect, except that of mineral structure, entirely different from the ordinary varieties of this substance. Their granitic aspect is still further expressed in a most striking manner by the spiry forms of the summits, by their hard serrated outline and their overhanging masses, a disposition by which they are rendered inaccessible even to the stags and the wild goats that roam over this region of solitude and rocks. To this is owing their highly picturesque aspect, which bears a striking resemblance to that of the granite hills of Arran, or the more stupendous masses of the granitic

Alps. It offers one instance among a thousand others of the little dependence to be placed on the characters of the outline in determining the nature of mountains, and shows how easily geologists, who have assumed the certainty of such a criterion and used it in their investigations, have been led to deceive themselves, and have contributed to the deception of their readers. But I must proceed to particulars.

Many varieties of rock are found in these mountains, of which some appertain to the trap family more strictly speaking, and others to the clinkstones, a set of rocks which, although they are intimately associated with these, possess also some other natural affinities, which may render it more convenient to consider them as members of another division. The phenomena to be observed in Sky are however insufficient to illustrate the views on which I am inclined to allot a place for these rocks in the system, for which reason I shall reserve these remarks till another occasion, when more numerous and more explicit facts will enable me to make the evidence proceed hand in hand with the theoretic arrangements to be established on them. I shall therefore content myself with describing the several rocks in a general way, since an attempt to investigate their connections more accurately, would involve too large and unjustifiable a portion of conjecture.

Greenstone appears to be the most prevalent of the rocks which form this group, and it varies very much in its character in different places. It is often of the most ordinary aspect, consisting of the usual admixtures of hornblende and felspar, and not at all distinguishable from those which appertain to the stratified parts of the island. This modification passes as usual into one in which the constituent parts, from their minuteness and intimacy of mixture,

cannot be distinguished, and which ought therefore to be considered a basalt, since no other criterion can be established between the two, the variable proportions of hornblende and felspar alone admitting of no better or more defined limit than this. More generally in these mountains the greenstone assumes a large grain and very coarse texture, and in some cases the separate substances exhibit crystals of a quarter of an inch in dimension, while the hollows which are found in the rocks are sometimes occupied by detached crystals of hornblende. The felspar in these examples is often of a greenish hue. This rock appears remarkably permanent, showing few traces of waste or decomposition of the surface, and it is of this particular variety that the rugged summit of Garsven is composed. Among the finer grained varieties a remarkable kind is found on the borders of the romantic lake Coruisk, where it lies in detached blocks rolled down from the surrounding mountains. It is honey-combed into large cavities, which allow the hand to enter deeply within them, while at the same time the surfaces are almost as fresh as if recently broken, showing none of that rusty stain which attends the decomposition of greenstones in general. These blocks are extremely sonorous, and, notwithstanding their thickness, they ring when struck, with a sound as great as, and precisely similar to, that of a thin vessel of cast iron. In other places the same rock is found studded over with large detached protuberances resembling pedunculated fungi, or huge nails driven into it. The last variety which I shall mention is found in the same place, and it is the most remarkable, since it presents a modification of trap hitherto undescribed. It forms a great portion of that naked and wild surface which I have already described in the general account of this spot, being disposed in enormous smooth inclined beds extending, without fissure or trace of decom-

position or fragment and without symptom of vegetable life, from the borders of the lake to the summits of the mountains. Of its interior extent I have no means of judging, since it is inaccessible. This rock is composed fundamentally of felspar and hornblende, the parts being always distinct and crystallized in various sizes, so as to form varieties more or less coarse. The felspar predominates in the compound, and is either glassy or inclining to that variety; at times indeed quite opake. To these is superadded hypersthene, but it is neither so abundant as the hornblende, nor is it found so generally dispersed through the rocks. It is traversed by veins of basalt, and by veins containing hypersthene in a larger and more distinct form.

The other rocks which are found in the Cuchullin hills may all be comprehended under the general term of clinkstone. I find it impossible even to conjecture the relative spaces which are occupied by the rocks of this division and the greenstones, but I have already said that the greenstones appeared to me most prevalent. In the southern parts of the Cuchullin they undoubtedly are so, but I am inclined to think that in Blaven, and in those hills which contain the light coloured syenite mixed with darker coloured rocks and which are as I have already noticed so easily distinguished at a distance, the dark rocks will be chiefly found to consist of clinkstone. The varieties which occur are as numerous as they usually are in the different situations in the western islands where this rock is found, with the single exception of Arran, which presents an infinite and instructive variety of them in all their modifications and transitions. In general the clinkstone is simple in its composition, and of a dark lead blue, which sometimes assumes a brighter hue, and occasionally passes through various tints to a pale whitish gray or ash-colour. In many places it is porphyritic, the porphy-

ries putting on a great variety of aspects varying with the colour of the base, the quality of the felspar which forms the crystals, their magnitude, and the density of their aggregation. Blaven offers a remarkable variety, in which solitary crystals of glassy felspar nearly two inches in length are sparingly disseminated through the ground. The beautiful variety consisting of pure white crystals in a ground of dark blue, which is found in Raasa, also occurs in Glamich. But it would be fruitless to describe these varieties. In the same hill it is found of an amygdaloidal texture, but, as far as I have examined, the cavities contain only crystallizations of epidote similar to those occuring in the greenstone which I have already mentioned.

Such are the rocks which as far as my observations extended form that mass, which, for want of a better general term, I have designated by the name of mountain trap. It is however evident that the rugged aspect and permanency of these hills cannot in any degree be attributed to the clinkstone which enters into their composition. We have examples sufficient in Mull and in Arran to show that hills of clinkstone always form in the progress of their decomposition a feeble and smooth outline. The same indeed occurs in these very hills, since the outline of Glamich, and of the other mixed hills in which clinkstone forms the dark part, is equally tame and rounded. From this knowledge we are led still more strongly to conclude that the hard and serrated summits, and even the main body of the hills which present them, are composed of some of the varieties of greenstone before described, and hence to conjecture that this substance forms their principal ingredient, and that the clinkstone is only found on those outskirts where the passage or change into syenite takes place. We have I fear no means even of conjecturing the causes of the difference either in the disposition or

in the durability of these mountain greenstones and those of the stratified trap, or of forming any probable conclusion respecting their æras of formation. Much remains to be learnt before we can attain to an accurate knowledge of these rocks, and there is much yet remaining for future observers in the ground which I have now trodden. But it is not an easy task to ascend these pinnacles and to traverse this rocky desart even in summer, and summer seems never to shine on them—at least it has never yet shone for me.

I must now proceed to consider the last rock which remains undescribed, the Syenite.

In describing the Cuchullin, I have for the sake of contrast introduced so many of the most remarkable features of the other group, which I have distinguished by the name of the Red Hills, that the less will remain to be said respecting them. They are invariably characterized by the lumpish roundness of their outline. The cause of this consists evidently in their rapid decomposition, and in the accumulations of fragments which cover not only their sides but their summits so completely, as to preclude in most places any view of the naked rock. Their elevation I have formerly observed is much less than that of the Cuchullin, and I have also remarked that they form a separate assemblage, interfering at their bases only by indentation or approximation, and being always distinguished from the latter both in character and composition. The summits most convenient of access are those of Ben-na-Caillich near Broadford, with its dependencies, and the somewhat insulated mountain of Glamich above Sconser, the highest of the group. As Ben-na-Caillich presents the greatest simplicity of composition, I will describe it first. It forms part of a group which descends into the plain by various acute ridges, reaching into Strathmore and the head of Loch Slapin on the southern side, and extending towards Scalpa

on the northern. It offers no remarkable variety of composition, but appears to consist of various modifications of that syenite about to be described, to which on a former occasion I proposed that the name should be limited, the syenite connected with the trap formation. Those who are acquainted with the syenite of Arran, of which the main constituent is felspar, will recognize in this a similar rock, of which examples may also be found in the neighbouring island of Raasa, as well as in many other of the Western islands. The hill of Glamich may be selected as a specimen of those which are formed of syenite and of clinkstone, both of which are in this case strongly marked, since, as already mentioned, the former displays its reddish yellow hue, and the latter a dark blue tint. In other respects there is no difference between these rocks in the general disposition, which is in both equally irregular and ill defined. I could not discover the contact of these substances, but am convinced from other observations that they are connected by a common bond of transition or of position, and that they present no essential differences in geological relations. As the syenite of this hill presents no peculiar varieties, and as the clinkstone has been already described, one common description of the former will serve for the whole group. There is probably cause for me to regret that I could procure no more extensive access to the hills of this group, but the uninhabited and desart state of this tract of country renders it nearly impossible, since the limits of the longest day are insufficient for their examination, and since the storms and rains of this wild island form but a dreary canopy to its rocky pillow. I can therefore add nothing more precise to the general idea I have already given of the connection of the syenite with the trap and with the clinkstone. The light coloured rocks which belong to the group appear in all cases to consist of the several vari-

eties of syenite which will be described hereafter, while the dark ones, with the exception of some greenstone, seem to be every where formed of clinkstone. The tendency of these syenitic substances to decomposition, explains the weathered appearance of the mountains which I have characterized by the name of the Red Hills, and the accumulation of the fragments which result from it, accounts for the roundness and tameness of their outline. These causes very generally impede the view of the natural rock. Wherever it can be seen it appears to possess the disposition which is I believe invariably characteristic of this class of rocks, forming large irregular beds, much rifted and fissured, and never continuous in inclination and extent for any considerable space.

It might be deemed important to determine here the nature of the junction between the dark clinkstone and the light coloured syenite, but if it has not been discovered here, it is fortunately visible in other places, while at the same time the community of these two rocks, in almost every circumstance but colour, seems to bespeak a common position. Ben-y-chat in Mull, and many situations in Arran, present examples of this connection, nay in some cases of a perfect transition. The phenomena visible in Rum, in St. Kilda, and in others of the Western islands conincide with these, and offer a proof which may by a fair analogy be extended to Sky, that there is a community of geological position in these two rocks.

I have much more reason to regret the insuperable difficulties which I experienced in attempting to trace the connection between the syenite and the stratified rocks, the sandstones and limestones which were described in the commencement of this paper.

The only real contact of this substance with those strata is to be seen at the marble limestone in Strath, and I have traced it in the

excavations made for quarrying that marble. I have always found the marble much indurated and very much coloured at the contact, being at the same time contaminated with silica and other earths; while the syenite itself in the same places appears rotten. Although in a general sense the contact of these two rocks may be said to be visible in various parts of this tract, some accident or other always occurs at the point of meeting, to prevent the real contact from being seen. If it is of small extent it is overgrown with soil and herbage; if it is of great dimensions, there is a chasm intervening which is filled with fragments and rubbish. Thus the contact at Kilbride, which would otherwise prove instructive, is overwhelmed and invisible. I was equally unable to find any place on the eastern side where its junction with the upper of the secondary strata could be observed, though it unquestionably takes place near Broadford; the soil is every where a deep peat completely covering the rocky surface. It may probably be found on the shores between Broadford and Scalpa. I know not that there is much to regret in not having seen more of its connections with these strata, since, if, as I believe is undoubted, it has the same relation to them as the trap has, no instruction further than that which we already have can be derived from such knowledge. It will be found indifferently interfering with every one of the strata, and consequently no judgment of priority or posteriority to any can be formed respecting it.

The basis of the syenite is a substance which having been generally received as a felspar, I shall describe as such, although not convinced of a sufficient identity in the composition of these two substances. In its softest state it may be considered as a claystone, since it offers no differences in character, while in a state of somewhat greater induration it becomes a clinkstone, and when more

hardened it is known by the name of compact felspar. As specimens occur in this simple state they must be considered mineralogically as examples of these different substances, although in a geological sense we cannot without troublesome circumlocution and great confusion consider them under any but the general term already adopted. The colour of this base varies from ochrey yellow and dirty flesh colour to gray: it is often cavernous and filled with a ferruginous clay. In other situations it contains crystals of felspar, either of the same or of a different colour, and thus forms various kinds of porphyry. The predominant form however is that whence its name has been imposed, an aggregate of felspar and hornblende, in which the hornblende generally bears a very small proportion to the other ingredient: the porphyritic character is sometimes added to this mixture. In some rare instances quartz enters into its composition, and in such instances it trenches near upon the syenitic granite, a distinction concerning which I have spoken in the paper on Glen Tilt, to be found in this volume. More rarely still it contains mica, and in this case it becomes utterly impossible to distinguish it from those granites which contain crystals of hornblende superadded to the usual threefold mixture of quartz, felspar and mica. Under such circumstances it is quite conceivable that specimens should be met with from which the hornblende was absent, since even in those I have described, it is very thinly scattered through the mass. In such a case, should it occur, mineralogy, unassisted by geological observation, would tend to mislead us in reasoning respecting its position, and we are thus driven to acknowledge, in geological description, the necessity of superadding to mineral characters an accurate knowledge of the connections of a rock respecting which we are reasoning: I must therefore, from a geological knowledge of

the position of these rocks, refer them to the syenite family, although had I met with the same specimens connected with a mountain of granite, and lying under mica slate, I should have referred them to the granites.

This is far from being the only case in nature where mere mineral distinctions are insufficient to determine the geological situation of a rock. In the stratified classes of rocks, both primary and secondary, these resemblances are frequent, since it is often impossible to distinguish quartz rock from sandstone, the breccias which it contains from the more recent graywackè, ancient clay slate from recent, or, as I have shown in this very account of Sky, primitive from secondary limestones. The same rocks seem in some cases to have been repeated at different epochas, while in others they show variations which may perhaps be the results of posterior changes operating on the first deposits rather than the consequences of original differences.

Two other varieties of this rock occurred to me which may be mentioned, although possessing no peculiar interest. In the one chlorite formed a constituent part, and in the other a greenish compact steatite was intermixed with the felspar and hornblende, the total compound being not much unlike the porcelain granite of Cornwall.

Before I conclude these remarks on the trap and syenitic rocks of Sky, it will not be superfluous to enumerate the striking external features in which rocks so nearly associated differ.

The mountain trap of the Cuchullin is most strongly distinguished from the stratified in the difference of its disposition, in the absence of the columnar forms and decomposing tendency, and in the barrenness of its surface compared with the deep soil and highly clothed vegetable surface of the latter. In its superior permanence, a per-

manence by which it appears to brave the external war of the elements which surround it, it is no less distinguished from the stratified trap than it is from the neighbouring Red mountains, whose rapidly decomposing summits covered with fragments have long lost their characteristic forms, hastening with daily and visible waste to the level of the plain below. It is equally distinguished by its general aspect, being commonly separated by marked features from the terraced trap with which it is associated, and no less so from the Red hills, with which, however associated in almost a common group, it forms no union. In mineral composition it also differs widely from these, hornblende forming its predominant and characteristic ingredient, as felspar does that of the latter. From the terraced trap it differs less in composition, since hornblende is the predominant ingredient of both, but it never like this contains amygdaloids and beds of tufo, neither does it entangle coal, sandstone or ironstone, or exhibit the beautiful zeolites so abundant in the terraced trap.

If there were any theory of the formation of the rocks of this class on which we could rely, it would not be useless to examine how far their distinctness of character and appearance was consonant to it, or how far they differed. Although my chief object has been to describe the geological features of the island, yet I may suggest that such an independence of character and form seems to imply at least that some independence in circumstances, as well as in time, has accompanied the formation of these several portions of a rock associated in so many other essential parts of their leading characters. But the time for discussing questions of this nature does not appear yet to have arrived, and conjectures may be left to the ingenuity of those to whom they afford a source of gratification.

With this rock I terminate the history of the principal rocks of Sky.

When speaking of the alluvial rocks, I did not mention granite, as I did not find any rolled stones of this substance. But as I observed it employed in the construction of a bridge not far from Sconser, I conclude that it is somewhere to be found and probably in this state, as I saw no reason to suspect its existence any where, as a fixed rock.

I have reserved to the last the consideration of the trap veins which are found in such abundance throughout the whole of this island, because, on account of their number and the interesting circumstances which attend them, they would have led to a perpetual interruption of that description which required to be unbroken. I have here, as on other occasions, applied to these veins the general term trap, for the same reasons which I assigned in speaking of the rocks of this class, namely, that they vary in composition, although basalt is certainly the prevalent substance in them here and every where else. The order which I have allotted for them in this description is also the order which they hold in nature, since they traverse every rock that lies in their way from the most ancient to the most recent, seldom suffering any change either of direction or composition in this varying course. As the same vein is therefore found to pass indiscriminately through rocks of all ages, it is plain that its association with these can afford no register of the period of its formation. If there were ten different periods in which these veins had been formed, we must be contented in most cases to prove but one, a period posterior to that of the latest stratified substance through which they pass. It is only where they interfere with each other that a register more extensive than this can be found. I have always assiduously sought for such examples wherever these veins abound, and, among other places, in Sky, but have never yet found more than two distinct sets. This number I have also observed in

Rum. Two distinct sets are perfectly visible both near Loch Scavig and at Strathaird, and the examples are unquestionable, since those of one period hold their course through the other in every direction, with the same pertinacity and distinctness as the first do through the fundamental rocks. We have no means of knowing what distance of time has intervened between these veins. The angle of their courses with the horizon is various, but in a very considerable proportion it is vertical or nearly so.

They are of frequent occurrence in the mica slate of the district of Sleat, and, as far as I have seen them, they are here basaltic. They also abound in the sandstone at Loch Eishort, where they are of considerable size. From this bed they are readily traced through the superincumbent ones as far as the most distant surface of the limestone, and here I have always lost them. In several attempts for that purpose, I never could discover their continuation through the syenite, and am therefore inclined to think that they are prior to it. To ascertain this fact, I caused a portion of the marble bed which was traversed by two of these veins to be cleared away to its contact with the syenite, and found that the whole mass terminated together against it, leaving in my mind little doubt that the syenite was posterior to the veins. This fact has a double bearing: it might be argued that the stratified rocks reposed on the syenite, since the nature of the contact between stratified and unstratified rocks is always such as to admit of a double interpretation, unless where veins of the one are seen decidedly ramifying from its mass into the other. But if, as in this instance, the trap vein, which we know to hold in all cases an unchecked progress through opposing rocks, is cut off by the unstratified rock, the syenite, it is plain that the stratified rock which that vein traverses has also been broken by it, and that the syenite in this particular case is posterior to the limestone, and of course to all that body of rock which precedes it.

It follows then that the syenite is posterior to the trap veins, and a further confirmation of this is found near Scavig, where a set of trap veins is also to be seen which traverses the red sandstone, but does not pass through the incumbent trap; therefore the syenite, and the mountain trap of the Cuchullin, are each posterior to one set of trap veins. This adds a probability to my conjecture, that the mountain trap and the syenite are of one period; it cannot be said to prove it because we have no means of knowing whether or not these separate sets of veins belong to one period or to more. Community of structure proves nothing in this case; they are equally formed either of a coarse basaltic substance, which can scarcely in strictness be called basalt, or of porphyritic trap; and would be with still less propriety denominated greenstone, since the two substances, whose distinct union forms this latter rock, and whose imperceptible mixture is supposed to form the other, cannot be traced in it.

But I must not terminate the history of these veins which appear in such a profusion of intersections in the vicinity of Scavig, without remarking that however numerous they may be, and consequently however large the space which they occupy, they produce little or no disturbance in the regularity of the sandstone beds which they traverse, nor does that rock appear to undergo any alteration in their vicinity. This remark will appear the more necessary hereafter, when I shall describe a similar but infinitely more striking phenomenon at Strathaird.

There is a second set of veins however, which traverse not only the mountain trap but the veins first named, and which are clearly of a posterior date. These are much smaller, often indeed not exceeding half an inch in breadth, and are composed of an extremely fine and hard black basalt. They are less abundant than the first where even they exist, and they are not found in nearly so many

situations. They are to be observed pretty frequently passing through the rock at Coruisk, and through the greenstone and clinkstone of Garsven, in the neighbourhood of which latter they abound. Their compactness and lustre are frequently so great that they approach in appearance to that pitchstone which forms the basis of the beautiful columnar porphyry of Egg. In addition to this feature they are strongly distinguished from the trap veins that traverse the sandstone by the intimate and almost inseparable union which they form with the body of the rocks which they traverse, whereas the latter are separated with the greatest ease.

There is still another set of veins found in this place, which however even and compact they may appear on a fresh fracture, and thus resembling basalt, appear to consist of clinkstone. This may be concluded from the facility with which they decompose at the surface into a greyish or whitish earthy looking substance, and from the depth of that decomposition. They are further distinguished by the frequency and minuteness of their ramifications, which are often drawn out to the size of a thread. Veins of this description have not as far as I know, been noticed, but they are not uncommon in the western islands, and they abound particularly in some parts of the Long isle; in this place they are chiefly seen on the borders of the small and picturesque lake Coruisk, and are found traversing the hypersthene rock, as well as the veins themselves, which consist of this mineral.

Having now described the trap veins which pass through the mountain trap, and those, perhaps more important ones as far as relates to that rock, which do not pass through it, I must turn the reader's attention to those which are found in the stratified trap. These are not very abundant, but may be seen distinctly among other places on the western shore, traversing the lofty cliffs in various

but generally perpendicular directions. They are of a very large size, and are frequently stratified, a circumstance not uncommon in basaltic veins. They do not resemble the small ones of the second rank which I have described already.

If, as some have seemed inclined to do, we should adopt a notion that all trap veins were of the same period, the existence of these in the stratified trap, while they were absent from the mountain trap, would lead us to conclude that this latter was a posterior formation to the other. This is possible, and I have certainly no proof to the contrary. But from what I have shown respecting the certainty of two distinct sets of these veins, and the possibility of more, it is plain that they can prove nothing respecting either the difference or identity of these two rocks. If there are two sets of veins there may be three or more.

As no useful purpose is served by describing all the trap veins which abound in these countries, I shall pass over many which offer no interesting features in themselves, and are of no evidence in geological induction, and finish by describing those that are to be seen at Strathaird, which are well worthy of notice on account of their extraordinary number, and of some particular appearances by which they are distinguished. I have already slightly mentioned them in the general description of this coast: I must now be more particular, and, to give an idea of their general appearance, I have subjoined what must rather be considered as a plan than a drawing, since the formality of the subject admits of nothing else.* I pointed out their extraordinary numbers, and may now add that in consequence of their frequency they nearly equal in some places, when collectively measured, the stratified rock through which they pass. I have counted 6 or 8 in the space of 50 yards, of which the collective di-

* See Pl. 4. fig. 3.

mensions could not be less than 60 or 70 feet. This remark is not mere matter of curiosity, it leads to geological inferences not unworthy of regard, as will be presently seen. Their direction is almost invariably either vertical or slightly inclined from the plumb, and they present therefore a perpetual parallelism along the coast. They are equal throughout, and never ramify, and although they vary from 5 feet to 20 in breadth, they more commonly are of a dimension not exceeding 10 feet. It is well known that the permanence of trap veins is sometimes less, sometimes greater than that of the surrounding rocks. Hence they sometimes project like walls, while at others their ruin produces fissures or caves. This latter effect has taken place here, marking a great tendency to decomposition in these veins, since the including rocks do not seem to be of a very durable nature. The depth to which they have been excavated is often very considerable: in the case, of the spar cave including the external fissure, it cannot be less than 250 feet. In consequence of this wasting it happens that the intermediate cliffs which remain, have, as I have noticed in the general description, the appearance of the ends of walls; and as they also sometimes yield and fall away behind, in such cases they present the appearance of insulated square pillars of masonry, the resemblance being rendered perfect by the channelled marks of the strata formerly described. These veins are often stratified, or more properly speaking, laminated in the direction of their length. They are generally formed of a bluish black basalt; at times they are porphyritic, or vary in other ways, which it is unnecessary to describe. I observed in one nodules of prehnite, the only occasion on which I have found that mineral in veins of trap. In another I found a second vein, holding a serpentine course through the first in a somewhat parallel direction, and readily distinguished by being formed of a much more black

durable and compact basalt. I have given a sketch of it. (Pl. 2. fig. 3.) I may finish the description by saying that the continuations of these veins are to be seen between Swenish and Kilbride, at least, veins similar in appearance and equally numerous, but that there is no trace of them on the opposite shore of Sleat in the places which their prolongations would cut: they are not therefore extensive in their courses.

It has been so general an observation that the courses of trap veins are attended with disturbances of the accompanying strata, that it seems almost to have passed into a rule among geologists. The present instance is a most remarkable one to the contrary. Although they are here so numerous, not the slightest disturbance takes place in the evenness and the horizontality of the strata of sandstone which they intersect. There is neither contortion, bending, fracture, or displacement, nor do they appear to have affected the texture of the rock, since it is the same both at the place of contact and at a distance from it. Of exceptions to general rules it is rare to meet with any so pointed and so strong; and though there is no room for any long commentary on it, I cannot entirely quit this very remarkable place without pointing out one extraordinary effect which must have resulted from the intrusion of these veins. If the lateral dimension of the collective veins is assumed at one tenth of that of the stratified rock, (and I have reason to think this estimate not excessive) it is plain that the stratified rock of Strathaird must have undergone a lateral extension equal to that quantity; a motion so great that it is extremely difficult to reconcile it with the present apparent repose and regularity of the whole.

I shall now proceed to describe the mineral substances which I observed in Sky, having reserved these details for separate consideration, lest they should interrupt the connection of the geological remarks which form the preceding part of this paper. The most numerous, and not the least interesting of these minerals, are those of the zeolite family. They are to be seen in various parts of the island, but are to be found in the greatest beauty and variety in the cliffs of the western shore between Loch Bracadale and Loch Brittle. Talisker, as it is the most accessible of these places, so it presents the richest assortment to the collector of specimens. But in general the mineralogist can have no access to any specimens but those which fall from the cliffs, and have long been exposed to the violence of the sea and the injuries of the air. However splendid therefore, they may once have been, they are not always to be found in a state of good preservation. It is moreover often difficult to gain access to them on any terms, particularly along the other points of this wild shore, since it is so beset with rocks on which a dangerous surf is almost always breaking, that it requires neither common good weather, nor common dexterity in the management of a boat, to effect a landing and retreat without hazard.

Analcime is the most common of all these minerals on the shore to which I have now alluded, and it is found in the greatest profusion at Talisker. It sometimes occupies cavities of considerable size, in different varieties of the trap, but seems to be by far the most abundant in those earthy and little compact sorts, for which there is no name in our catalogue of terms. In other cases it forms flat druses of considerable extent, occupying the walls of fissures, while in a third, a single crystal is sometimes seen in a cavity just sufficient to contain it. In the greater number of instances the remaining part of such cavities is filled with the filamentous meso-

type hereafter to be described, and the crystals thus seem to be imbedded in a mass of cotton.

The size of the crystals varies from that of a pin's head to the diameter of half an inch; but in general they present only one modification, the twenty-four sided crystal with trapezoidal faces, of greater or less regularity. The only other form which I found was the primitive, and of that I procured but two specimens, while a ship might be loaded with the trapezoidal variety. The crystals described are sometimes opake and white, at others they are mottled with a mixture of opake and transparent parts, while in a third, but less common case, they are transparent. In this latter case, when minute, they sometimes transmit the black colour of the subjacent basalt to which they adhere, so perfectly as to resemble a velvety surface of black crystals. In similar circumstances, transmitting the greyish or ochry colour of the substance to which they are attached, they appear to possess a colour which a more narrow inspection shows to be fallacious. A few specimens however occur of a flesh red, a colour frequently found in almost all the minerals of this family, and very predominant in the different zeolites which occur at Glen Farg in Perthshire. I also found a solitary specimen of a pale sea green colour, but did not observe that variety of a pale bluish grey, which, in company with the flesh coloured and yellow green, I have seen in the rocks at Larne in Ireland.

Chabasite is found in similar circumstances on the same shore, but it is comparatively of very rare occurrence: it abounds however in the rocks at the Storr, which for a considerable space consist of an amygdaloid containing it accompanied by stilbite. It is here so common, occupying cavities of greater or less magnitude, that a fourth or fifth part of the total bulk of the rock is sometimes constituted by the chabasite.

As far as I have observed, the chabasite which I have described is never, like the analcime, imbedded in the filamentous mesotype, but is not unfrequently associated in the same cavity both with stilbite and with analcime, nor is it unusual to find minute and well formed crystals of this latter substance, imbedded in the crystal of chabasite. In some cases perfect crystals of chabasite are lightly sprinkled over the surface of crystals of stilbite, adhering so slightly as to fall off on the slightest concussion: in other cases crystals of this mineral, as well as of the analcime, are confusedly mixed with rhomboids of carbonate of lime, hereafter to be described.

The primitive crystal of this mineral is by much the most common, its modifications being rare and offering but few varieties; it is very frequently twinned, the angles of the one crystal appearing on the faces of the other, nor is it uncommon to meet with it in triplets, or even in more complicated groups, displaying an irregular mixture of prominent angles. The most common modification consists in the truncation of one angle; sometimes two neighbouring angles are truncated, and occasionally this defect extends to three, the truncations being often so deep as to remove a third part of the rhomb. In other modifications a single angle and a single edge are removed, or the truncations extend to two angles and two edges; but I have not observed any specimens in which these defects were extended to a greater number of edges. The edge is in some cases replaced by two or by three planes, or even by a greater number, so as to appear nearly rounded; and each face of the rhomb is also frequently replaced by two planes meeting in an edge diagonally extended and sometimes rising by successive stages of planes parallel to the original face.

These crystals are sometimes opaque, more frequently transparent, but in by far the greater number of instances they acquire a

fallacious aspect of opacity in consequence of innumerable minute fractures by which they are pervaded throughout; they are most commonly white, but the flesh coloured variety is also found: their magnitude varies from the twentieth to that of three tenths of an inch in breadth.

Stilbite is perhaps the most abundant of these substances which Sky produces, and it appears to be the most generally diffused throughout the island; it occurs along the shore which I have described, but in less quantity than in the northern district. It is so common in some places in the parishes of Kilmuir and Snizort that it is scarcely an exaggeration to say, that the roads are sometimes almost made of it. In some situations the decomposed trap falling into a powdery soil, leaves large accumulations of it resisting the action of weather long after the rock has mouldered away, while in other places it has been converted itself into a friable mass, which, as I already remarked, has been mistaken for marle and used as manure.

It presents scarcely any varieties of crystallization: the predominant, I might almost add the universal form, is that most common one consisting of very flat tetraedral prisms, terminating in tetraedral pyramids, of which the faces are placed on the edges of the prism. These are aggregated in distinct fasciculi, parallel or divergent, of which the groups sometimes affect the form of the constituent crystals. In the neighbourhood of Loch Eynort I observed some specimens of great beauty, consisting of large and distinct square prisms terminated at each extremity by truncated tetraedral pyramids arising from the edges, the crystals being transparent and nearly an inch in length, adhering slightly by its side to the quartz crystals of the chalcedonic nodule in which it was formed.

In the same place I found nodules of great size, and of a variety which is far from common, but which has I believe been found in the Faroe islands. The nodules in question are either hollow or solid, and sometimes reach the enormous dimension of four and even five feet. The hollow ones are crystallized within in the fasciculated forms already described. The peculiarity of this variety consists in its extreme frangibility: the least effort is sufficient to detach the plates of which its structure is formed, and it therefore falls to pieces in the very act of procuring it, unless great care is taken; its fracture is fresh, and distinguished by an uncommon degree of the pearly lustre which is so characteristic of this mineral. So great is its frangibility, that the jarring of the hammer at one end of a large nodule is often sufficient to destroy the whole; and it not unfrequently happens, that when a large piece is obtained entire and has been laid down, although it appears uninjured and resists a strong effort of the hands to break it, yet in a few minutes it falls to pieces with a sort of violence not unlike that which is known to happen in unannealed glass that has received an injury. This variety is sometimes white, and much resembling spermaceti in its translucency, but in the greater number of cases it is of a delicate flesh colour.

The next of these minerals is mesotype, and it is found in three states, a compact, a mealy, and a crystallized form. Of these the compact varieties sometimes recede so far in character from the mineral in its most acknowledged forms, that it is only by tracing the gradation of the several varieties, that we are enabled to determine the names of those which occupy the distant points of this range. The opake whiteness, the toughness, and the radiated disposition of those specimens which may be considered as forming the first remove, serves to connect them with the best characterized

ones. By a series of gradations the radiated structure disappears, while the mineral acquires additional toughness, verging in its aspect first to chalcedony, and lastly towards chert; while in some cases it would be difficult to distinguish it, without trial of its hardness, from the white limestone of the north of Ireland: in this state it is not scratched by hard steel, while its toughness is such that a heavy hammer makes no more impression on it than it would on a similar mass of iron. The last transition is into a perfect chert, scarcely to be distinguished from those which in other situations occur in trap, and which are so frequently to be seen in those traps where nodules of calcareous spar and of chalcedony are found together.

If we were to reflect on the causes of this gradual change, we should attribute it to the successive diminution of the proportions which the other constituent earths of this mineral bear to the silica which it contains. I need not point out the difficulty of reconciling such a supposition to the general theory of mineral species and of definite proportions, since mineralogists are already aware of it, and since many other cases, attended by similar doubts, are well known. It is a question too important to be discussed without much more numerous and better established facts than those which we yet possess, and it will hereafter become an object of serious investigation to mineralogists, when their science shall have made further progress.

That variety which is called mealy is also here presented under different aspects, by which its nature is in some measure illustrated. This condition has, I believe, been generally attributed to the loss of its water of crystallization, the result of decomposition. It is obvious however that this is not the cause, since the specimens of this variety are found in the centre of solid nodules, of the glassy

kind, where neither air nor water can have access, and where they are accompanied by crystals of absolute transparency: they are also found intermixed with and investing solid nodules of the toughest varieties, deeply imbedded in large masses where the elements are effectually excluded from them. This mealy variety appears in three different forms: in the first it is disposed in a radiated or rather in a ramose manner, in fine fibres possessing the peculiar lustre and softness of the finest white pulverulent talc. In a second case it forms distinct globular concretions of extreme minuteness, not to be discovered without the aid of the lens; and in a third instance, which I observed near Loch Eynort, a mass of globules of solid radiated mesotype, very much resembling some of the oolites, is intermixed throughout with farinaceous scales of the same substance, having the greasy aspect and lustre already described.

In speaking of this substance I have, according to common usage, ranked it with the mesotypes, it appearing to have been thus placed, partly because it is found associated with them, and partly because of the theoretical views which have been held respecting its origin. It will be for mineralogists of more authority to consider whether it does not deserve a separate place as a species: the question is evidently of a nature not to be determined by geometrical analysis, as far at least as the varieties already found extend; and the delicacy and uncertainty of unassisted chemical analysis in questions of this nature, are far too great to tempt us to seek a new place for it by this kind of investigation.

The last variety of mesotype exhibits a distinct crystallization; but crystals of tangible magnitude are so rare that I only procured one specimen in which the forms could be determined. They sometimes consist of a square prism, considerably elongated: in

one case all the edges of the prism are replaced by planes, while in another, by the unequal truncation of three angles of a parallelopipedon, a pentagonal prism is produced. These prisms sometimes terminate in a pyramid, the faces of which correspond to the planes of the prism, and which is either complete or truncated: in other cases greater irregularities take place, but the extreme minuteness and transparency of the crystals frequently renders it impossible to ascertain their exact nature.

To compensate for the deficiency of large crystals of this substance, a profusion of that variety is to be found, which bears a general resemblance to amianthus, and it is popularly known in the country by the name of cotton stone. These filaments occupy the cavities of the trap, and are sometimes accompanied by analcime, as has already been remarked. They vary much in minuteness and delicacy, as well as in their state of aggregation, and hence many variations in their external aspect may be observed. At times they are placed in distinct straight needles, in other cases they are crowded into a dense mass, while in a third they are so entangled as to resemble a lock of cotton wool. Frequently they have the lustre of common silk, with its apparent dimensions, while they are in some instances so far attenuated as to resemble the silk of certain spiders. When the trap has fallen into powder, they are occasionally detached in light compacted balls, which are blown away by the winds and float on the surface of the water: in all these cases the microscope discovers their glassy transparency, but its powers are insufficient to determine their form, from the dazzling play of reflected and refracted light which they exhibit. In some rare instances this variety seems as if it passed into the mealy; in reality it becomes opaque and puts on to the naked eye a mealy aspect, which is however readily distinguished by the lens, from

the specimens which I have described above. The last specimens in point of structure which I shall notice, consist of radiated mesotype intermixed with crystals of hornblende, and producing a compound of an unusual appearance.

The specimens which I have now described are almost invariably colourless and transparent, or white, but occasionally they assume a brown tinge. One specimen occurred of a sea green hue and of perfect transparency; but the flesh colour not uncommon in this mineral did not fall in my way, although found in the other members of this family which are seen here.

With respect to the exact locality of this substance, I have only found it at Talisker and at Dunvegan, although it is probable that it exists in many other parts of this very extensive island, which the labour of years would scarcely suffice to examine with the scrupulosity necessary for this purpose.

It was at Dunvegan that I observed a solitary crystal of ichthyophthalmite, nor did I succeed in discovering a second. It appears that laumonite has been also found in Sky: in the course of my researches I observed some minute specimens of it associated with stilbite, but scarcely worthy of notice, unless for this slender record of their habitat.

Prehnite, a mineral so nearly allied to the zeolites, is also found in Sky, but it is far from common, while the specimens are at the same time of trifling magnitude. It occurs in the trap at Portree, and at other points along the eastern shore, as well as at Strathaird, in the trap veins which traverse the sandstone, as I have already mentioned. On the shores opposite to the point of Clachan in Raasa it is found in a rock, which, although not very common, occurs in different parts of the western islands. This rock is a compound of augite, glassy felspar, and common felspar, the

two latter having frequently a greenish hue. Besides the decided nodules of prehnite contained in it, the same mineral is intermixed throughout the rock, forming an integral part of it, and often passing into mesotype, as it appears to do in other more decided instances. It has been said by Haüy that prehnite has not been found forming an integrant part of rocks; but as a compound of a similar nature occurs in the Kilpatrick hills near Glasgow, an exception must be made in favour of these instances. I may here add, that a corresponding rock may be seen on the opposite coast of Raasa.

It is perhaps superfluous to say that nodules of chalcedony, often hollow and containing crystallized quartz, are occasionally found in the trap rocks of Sky, since they are of such common occurrence in this substance. The cavities are sometimes, in addition, sprinkled with crystals of stilbite, of analcime, and of chabasite.

Of those mineral substances which are the least frequent in trap rocks, steatite occurs in considerable quantity; it is tender, and always of a greenish dirty hue. It is sometimes found in very small nodules; but in other places, as near Dunvegan and in the parish of Kilmuir, it is so abundant that it has been dug up with the intention of exporting it for economical purposes.

I have already mentioned that epidote is found both in the clinkstone and in the trap, but in too small quantities to render any further account of it necessary. It is thus far worthy of notice, as it is one of the few minerals which seems to appertain to rocks of very different characters and periods of formation.

The carbonate of lime to which I alluded when speaking of the chabasite, is found in company with this mineral and with the analcime, occupying along with them cavities in the trap: it presents but one form, that rhomb which is called the inverse, and

it varies considerably in its dimensions: it is sometimes white, but most generally of a honey yellow colour, but I must add, that in either case it is of rare occurrence.

The last and the rarest mineral which I discovered in Sky is hypersthene. This occurs at Scavig, in that singular variety of trap which I have already described in the account I gave of the Cuchullin hills: it forms veins of different dimensions and much blended with the rock in which they lie, but they are neither numerous nor large, nor are the veins simple in their composition, since they resemble the containing rocks in the different substances of which they are composed. The most prevailing mixture is however that of hypersthene, and of a dark felspar precisely resembling that of Labrador in its general aspect, but not possessing its iridescence. This felspar is frequently crystallized, but as the crystals are always completely imbedded, nothing further of their form can be discovered than the outline which is displayed by the fracture: together with the dark felspar, white and glassy felspar also occurs in the mixture, and the common opake white variety is sometimes, but more rarely, intermixed with all the other substances. It has been already noticed that these veins are traversed by veins of clinkstone and of basalt, and they are also intersected by veins consisting of common white felspar and quartz, sometimes confusedly intermixed, and at others disposed in the graphic form. This opake felspar is sometimes distinctly crystallized in cavities. Rarely mica occurs in the compound, and in one specimen I observed transparent green crystals so minute and so imbedded that their nature cannot be ascertained: they have the aspect of olivin. Pyrites is occasionally seen, interspersed among these substances, but it is also rare.

The hypersthene presents specimens of great magnitude and

beauty, which, although they seem to resist the injuries of time far longer than the accompanying substances, at length also become rotten, and fall into an ochry powder. Distinct concretions are to be found exhibiting the primitive form, and which appear to be true crystals, since they are detached from the surrounding substances. More generally however, it is without form, while in many cases it is intermixed with the dark felspar so as to present the graphic character, the crystals of felspar being defined, and the hypersthene occupying the interstices. The lustre of this mineral is always highly metallic, but the specific gravity of the specimens which I examined did not exceed 3.342. The colour is various; in general it is of a purplish black, sometimes steel grey, and more rarely of a pale whitish grey, while it often assumes the hue, together with the lustre of polished brass, when it has long been exposed to the air.

Hypersthene has been found in Aberdeenshire, but the circumstances which accompany it have not been described, nor the nature of its connections ascertained. As far as can be determined by this instance, it must be considered as an inmate of the trap family. Having also found it in the island of Rum associated with the same class of rocks, additional confirmation is afforded of this connexion. That of Labrador is known, like the present, to be accompanied by dark felspar; but the rock which is the common repository of both has not been described by the missionaries, to whom we are indebted for the only knowledge we possess of that country. Mr. Giesecke considers the Labrador felspar of Greenland as belonging to what he calls the "Syenite formation," and it is not improbable that his syenite formation resembles the rock which I have already described, and that there is a correspondence in the repositories of this substance in both countries.

Among the rocks, for which I could not find a place in the geological description without disturbing its order, pitchstone requires to be noticed. Although not found *in situ* it offers as a mineral specimen some appearances which are interesting, and which I shall therefore describe. It was on the hill of Glamich that I found the specimens in question, and it is probable that they had been detached from some veins which I was unable to trace. There are two varieties, a black one very little differing from that of Rum, except that it contains a few dispersed crystals of glassy felspar; and an olive green one, which as it offers some apparently important peculiarities hitherto unobserved, I shall describe more fully. It is often of a granular combined with a small conchoidal fracture, and is generally disposed in distinct concretions which are either of the flat or curved lamellar form. It is remarkable for containing irregular rounded cavities similar to those of the amygdaloids, filled with compact grains of a grayish hue. The structure of these is so singular as to be deserving of notice. On breaking the smaller ones they are discovered to consist of a grayish white enamel similar to that which is formed by the fusion of felspar. But if we break the larger grains we can distinctly see that the center is composed of glassy felspar, the crystalline transparency and platy fracture of which are perfect, while the surface to a certain depth is converted into the white enamel I have described. I have not observed this very peculiar and striking appearance in any other pitchstone which has come under my notice, although there are appearances not much unlike it in some of the varieties found in Arran.

Those who conceive pitchstone, like basalt, to be of igneous origin, will have little difficulty in explaining this phenomenon, and will even find in it strong evidence to support that theory. It is unnecessary to enter on a reasoning so obvious.

I have concluded, perhaps without sufficient evidence, that the pitchstone both of Ben-na-Caillich and of Glamich, has been detached from veins. This deduction is made from the small quantity of fragments which are to be found, and from the circumstance that all the pitchstones of Scotland hitherto observed actually occur in veins.

A large portion of the summit of Glamich has the power of affecting the magnetic needle at even a considerable distance, a property extremely common in the rocks of this family. I was desirous of ascertaining if any regularity existed in the position of the magnetic poles, similar to that which Humboldt has observed in a rock of serpentine which he has described: for which purpose I observed the affections of the needle over many parts of the space as far as that was accessible, and I have represented them in the accompanying diagram, Pl. 3, fig. 1.

A consideration of those positions in the diagram will explain immediately that which would require much circumlocution to describe in words. In five places, extending from the eastern to the south-western side of the ground included in the circle, it will be seen that the needle remains uninfluenced. At the northern limit of the hill its position is equally true, but from the strength of its polar tendency, I conceive it was there affected by the coincidence of its position with the meridian of some neighbouring magnet, although by some oversight I neglected to take any other bearings near the same spot which might have verified this supposition. On the north east rhumb in five several places taken at the distance of five yards from each other, the positions are such as could not result from the influence of any one magnet, however

that may be conceived to be placed. This discordancy of position is still more remarkable in the several parts of a neighbouring line running on the E. by N. rhumb, and proves clearly that several magnetic bodies exert their influence in producing the disturbance which is there visible. Were it necessary to confirm this by any other observation, it would be fully proved by its deviation at a distant point situated near the N.W. part of the circle, where its position is such as to be evidently produced by some magnet unconnected with those which cause the great irregularities crowded together in the two places immediately before described. If I understand rightly the account which Humboldt has given of the affection of the needle by the hill of serpentine which he describes, it would appear that the whole rock consisted of a single magnet acting with great regularity on the needle. But in this case it is plain that its deviations from the true meridian are the consequences of the actions of several magnetic bodies dispersed over the summit of the hill, from the intricacy of whose combined influences it will evidently be impossible to determine the precise position or extent of any of them. It is probable that the meridians of all these and similar magnets occurring in the basaltic rocks, or in other rocks, are coincident with the magnetic meridian, and that they acquire this virtue as masses of iron are often known to do by long continued rest in favourable positions, combined probably with circumstances of which we are as yet doomed to remain in ignorance, little acquainted as we are with the history and causes of this obscure power. But I need not dwell longer on this particular example, since in a paper on Glen Tilt, which will be found in the present volume, I have entered at some length into the general question.

Among other matters I have reserved for this division of the present paper, the very little information which I was able to procure respecting the coal of Sky. Appearances of it are to be seen in several places in the trap, as I have already cursorily noticed, and among the rest a solitary mass of some thickness is found near Talisker, but in a part of the cliff nearly inaccessible. It is here as in most similar cases mixed with bituminous wood. Coal has also been found at Portree, and some fruitless and expensive attempts have been made to work it. Thin edges of seams of coal may also be observed in different places in the parish of Kilmuir, together with the carbonaceous rubbish which so generally indicates their presence. Under the direction of Lord Macdonald some borings and examinations have been made by coal surveyors, but, for reasons of too frequent occurrence among the itinerant professors of this branch of surveying, I found that no dependence could be placed on their reports, nor did my time permit me to institute such an examination as would have been required to ascertain the true state of things. The anxiety of the inhabitants and of the proprietors of the western islands in general for the discovery of this mineral is such that they are readily misled into the search, and coal mines have even been pointed out to me in micaceous schist. Nevertheless it is not unlikely that the district of Kilmuir may contain coal, since the sandstone and accompanying strata which I have already described are such as we should expect to find it conjoined with, and since in the island of Egg similar strata are actually accompanied by very minute laminæ of that mineral. But there is no great probability that this coal, even if it were proved to belong to these strata and not to the accidental fragments dispersed in the trap, like the one at Talisker, could be worked as a matter of

oeconomy, since the perpetual interference of the trap rocks an the disturbance occasioned by them, would render it too expensiv an undertaking

Among other substances I have reserved to this place the descrip tion of the siliceous schistus which is to be seen at Duntulm, o account of its partial nature and because its history would hav interrupted the connection of the geological details. I have alread mentioned that the trap found in this vicinity is obscurely colum nar, forming high and picturesque ranges of cliffs surmounting th hills and extending to the sea shore. I have also noticed in genera that beds of shelly limestone and of sandstone, containing shell and carbonized wood, alternating with shale, are seen under it. Bu the most interesting appearance is that of a disrupted portio of a thick stratum of the schist, known by the name of siliceou schist, and of that particularly hard and black variety which ha been called Lydian stone. This rock forms a portion of a bed th base of which is covered by the fragments of the shore, but its visibl thickness is about twelve or fifteen feet. It is surrounded on all side by, and lies under, a mass of obscurely columnar trap, the junctio being in many places attended with great confusion, (Pl. 2, fig. 3.) It is divided into thin laminæ, of which the upper ones alternat with similarly thin laminæ of sandstone, precisely resembling thos alternations of shale and sandstone which are so common an so well known. It is not indeed till fragments of the rock are ex amined in the hand that the spectator can discover that he sees an thing but a bed of shale alternating with sandstone: but on thu examining the schist, it is found to be an extremely brittle and har substance, of a black colour, giving fire freely with steel, sharp i the fragments, and with an obscurely rhomboidal fracture; this las character being the only one by which it can be distinguished fro

the fine grained basalts, particularly such as I have mentioned as occurring in the form of veins in the Cuchullin. The sandstone laminæ possess at the same time the hardness and jaspideous aspect of that which I formerly described* as lying in contact with the greenstone of Stirling castle. Considering therefore the analogy of these two sand-stones both in aspect and position, we may fairly conclude that they have in these instances been altered from their original texture, in consequence of the proximity of the trap rock. The alternation of the two substances here described, which have doubtless been originally shale and sandstone similar to that of the unchanged specimens which we meet with in various parts of this shore, gives us an equal right to conclude that the same influence of the neighbouring trap which converted the sandstone into hornstone, also converted the shale into Lydian stone. This in fact is the position of every specimen of siliceous schist or Lydian stone which I have seen in Scotland. In Cruachan, in Raasa, in Shiant, at Talisker, it forms beds, in contact with and involved in trap, which, from their connections and positions, appear to have been common clay slate, in those cases where it belongs to the primitive strata, and shale in those where it has formed a constituent of the secondary ones. It is possible also that the gray varieties of this substance may have originated from slate, and the black or Lydian stone from shale: additional facts however would be required to prove this part of the theory.

I have said that the resemblance between this Lydian stone and fine grained basalt is so perfect that there is no assignable difference of character save that of the large fracture, a circumstance of difference perhaps necessarily resulting from the unaltered stratifica-

* Geol. Trans. vol. 2.

tion of the Lydian stone. Nor is there any reason to doubt this resemblance, since the same materials under a different form probably compose both rocks. Chemical analysis unfortunately offers us no temptation to try this analogy further, since the variable composition of basalts as well as of schist, a variation necessarily arising from the circumstances of their formation, would prevent the possibility of comparing any two specimens even of the same substance. It may be an interesting matter of speculation to inquire by what power the vicinity of trap operates in influencing the change from shale to Lydian stone, as well as in producing the much better known changes which occur in sandstone bordering on trap. If basalts have been in any case produced by the fusion of beds of slate, the necessary analogy between the Lydian stone and basalt will appear conspicuous, and we have only to consider it as a shale brought into the state of basalt by fusion, without such further disturbance as to destroy its original stratification.

Although both the neighbouring sandstone and alternating shale which have undergone no change from the vicinity of the trap contain shells in considerable abundance, I did not perceive any marks of them in this bed of Lydian stone. They may nevertheless exist, although they escaped my observation. I have little doubt that the instances of basalt containing shells which have so often been described, have sometimes been cases analogous to this: the observers, attending to the composition rather than to the disposition of the rock, having easily been led into error from the perfect similarity of the indurated shale to fine grained basalt. I may venture to point out these instances as calling for re-examination.

I shall terminate this account of the minerals found in Sky, by a more detailed description of the marble of Strath, adverting to those oeconomical uses to which it seems applicable.

The following varieties are the most remarkable of those which are to be seen in this tract.

1. Pure white marble, the fracture intermediate between the granular and small platy.
2. The same with a scarcely discernible shade of gray.
3. The same with variously disposed veins of grey and black, resembling the common veined marble used in architectural ornaments.
4. The same with narrower veins well defined, and often reticulated with a great semblance of regularity: very ornamental.
5. The same, distinguished, independently of the veins, by a parallel and regular alternation of layers of pure white and grayish white.
6. White marble variously mottled and veined with gray, yellow, purple, and light green. This is also a very ornamental variety.
7. Marble, exhibiting various mixtures of white, pink, purple, light green, dark green, and black, of a rich sombre effect, and highly ornamental.
8. White marble, beautifully mottled and veined by yellow transparent serpentine.

The ornamental coloured marbles here described, scarcely yield in beauty to many of the similarly constituted specimens of ancient marbles, and like many of the marbles of Scotland they will be found to owe their colours to serpentine. This is also the case in Glen Tilt, at Balahulish, and in Iona. But the most obviously valuable variety is the white, which seems to possess most of the qualities requisite for the purposes of statuary.

Few substances in the catalogue of those with which economical mineralogy is concerned have excited more interest than statuary

marble, from its rarity, its beauty, and its indispensible necessity in the art of sculpture. It has at different times formed an object of anxious research in this country, and premiums have been held out for it by the Society of Arts. It has consequently been found in various parts of Scotland, as well as in Ireland, but no native specimens have yet been introduced into the arts. As the causes which have impeded their introduction have hitherto been such as may be considered adventitious, being of a commercial nature and not founded on any experience of their physical defects, it has been hoped that they might by perseverance and time be removed, and that the statuary marbles of this country might at some future day supersede the necessity of importing this article. It will not therefore be a misplaced inquiry to examine the several properties of those marbles which have at different times held a place in the estimation of artists, and to compare them with our own specimens, more particularly with that of Sky now under review, the most abundant and certainly the most specious of all those which have yet been found in Britain. The inquiry is the more necessary, as the several circumstances in which white marbles differ, do not appear to have been generally attended to, and as an undue value seems in some instances to have been fixed on our own in popular estimation, although not in that of sculptors themselves.

The value of this substance in those distant periods when the arts of Greece flourished, occasioned an industrious research after a material in which the sublime ideas of its artists could be embodied. Accordingly many quarries have been wrought in ancient times, of which little has descended to us but the names, and a few of the works which were executed from their produce. These marbles were of various qualities, and examples of them are still to be seen in ancient statues, although with regard to many of them, a species of

evidence, often little better than conjectural, has guided sculptors and mineralogists in their attempts to determine the quarries from whence they were derived. Among these, the quarries of Paros afforded a marble (the often quoted lychnites of Pliny) in which it is asserted that the celebrated Venus was wrought, as well as some others to which we have not access. But there are many specimens of sculpture in the British Museum which seem to have been executed in this stone, or in one at least of analogous character.

Of the nature of the Parian marble we are enabled to speak positively, since some blocks of it have been quarried during the last few years, and are now to be found in the shops of the sculptors of this city. The grain of this marble is large and glistening, while at the same time its texture is loose and soft, and its colour of a yellowish and watery white. It possesses considerable translucency on the edges, a quality which, however desirable in statuary marble when of a fine grain, from the softness which it gives to the outline, only increases the disagreeable aspect of the Parian, by the angular reflections of light which take place on the pellucid edge and surface, from the innumerable faces of the small plates. The specimens of sculpture which I am about to quote, will exemplify this fault. It is certain indeed that the Greek sculptors abandoned the marble of Paros after the quarries of Luna and Carrara were discovered, the superior fineness and whiteness of these marbles which at present cause them to excel any with the places of which we are now acquainted, rendering them also at least equal to the best of those ancient ones of which the native places are now unknown.

Independently of the injurious effects which the large grain of the Parian marble produces on the transparent surface of sculptured works, and the false lights which it thus introduces into the contour, it interferes materially with the requisite correctness of draw-

ing in the lesser works, and is thus inapplicable to the details of small sculptures in relief. It is nevertheless susceptible of a good polish, a quality however, of little value in the eyes of the statuary, and one which in this variety only serves to render the defects of its texture more apparent. It is also said to have been deficient in size, since it was so intersected by fissures as to be incapable of yielding blocks of more than five feet in length. I may add that in the present state of the public habits with regard to white marbles, there is no demand for modern works executed in Parian marble. Its celebrity is consigned to the metaphors of poets.

It will afford satisfaction to those who are interested in the arts to point out such works in the British Museum as appear to have been executed in Parian marble, or in one of similar character.

A Cupid bending his bow. This specimen is rather of a finer grain than the generality. It may perhaps belong to that marble called by the Italian sculptors marmo statuario, but this question cannot be determined without a fresh fracture.

A bust of Minerva.

Aratus, a bust. This also is of a fine grain like the Cupid.

A Venus, of a similar grain, and agreeing with the character of the marmo statuario.

Zeno, a bust, of a very coarse grain.

A terminal head of Bacchus.

A terminal head of Mercury.

A Jupiter Serapis.

Bacchus and Ampelus.

Marcus Aurelius, a bust.

There are others, but it is not requisite to enumerate them.

A marble of a much finer grain, and capable of a high polish, is described by the ancients, as found near the river Coralus in

Phrygia, as well as in some of the Greek islands: it is supposed to be the variety known to statuaries by the name of marmo Greco, and some ancient statues are described as being formed of this marble. It is possible that specimens of it may exist in the British Museum, but our sculptors are, as far as I know, incapable of distinguishing it at present, and it is much too hazardous to assign the place of a particular specimen from the contemplation of a polished and often of a stained surface. Mr. Tennant has found that the marmo Greco is a magnesian limestone.

I am equally unable to point out specimens of that variety known to the Italians by the name of marmo statuario, of which the quarries are also lost, but which, with greater translucency of surface, resembles the Parian marble in the largeness of its grain, unless those which I have conjectured to belong to this variety, when describing the specimens of sculpture in Parian, do in fact appertain to the latter.

The quarries of Luna produce a compact white marble susceptible of a high polish, and capable of being wrought with the most minute accuracy. Hence it is preferable for the finer operations of bas relief, either to the Parian, of which the aspect interferes with the delicacy of finish and of surface required in these works, or to the Pentelic, which was subject to accidents from veins of mica and of serpentine, or to that of Carrara, in which dark veins are of frequent occurrence. It was accordingly preferred by the antients, and among many other works, the Apollo (Belvedere) is said to have been executed in Luna marble. We have no other knowledge of the marbles of Hymettus and of Arabia than their names.

Of all the marbles employed in the works of the antients, and of which many specimens have descended to our days, that of

Carrara is almost the only one which is at present held in estimation, or is now accessible to modern sculptors. This marble is of a very fine grain and compact texture; it is also susceptible of a high polish when required, and is consequently applicable to every species of sculpture, except when, as is too often the case, dark veins intrude and spoil the beauty of the work. Notwithstanding the general apparent uniformity of its texture, it offers different varieties of aspect. It is always of a fine granular fracture, yet this fracture is sometimes combined with a slight tendency to the flat splintery, in which case the stone is harder and more translucent than when it is purely granular. When merely granular it is sometimes dry and crumbly, precisely as if it had been exposed to a high heat; it then loses much of its transparency, and is called *woolly* by sculptors. Its transparency is various, and in some cases nearly equal to that of alabaster, (granular gypsum.)

The bust of Marcellus in the Museum offers an example of a very fine grained and extremely translucent marble, apparently of this kind. The specimen employed in the bust of Messalina is equally remarkable for the fineness and beauty of its texture. In a bust of a youthful Hercules in the same collection the identity of the marble is marked by the dark veins which are to be seen in it; but it is unnecessary to quote individual specimens, as the greatest number of the sculptures in this collection appear to have been executed in Carrara marble.

The last of the antient marbles which I shall describe is that of Pentelicus, of which the quarries are probably still to be found in the vicinity of Athens, although they have not been investigated by modern travellers. But we are in possession of numerous specimens of sculpture in this stone, from which we are able to

determine its qualities; two are to be seen in the British museum. Of these there is the bust of a Philosopher, of, apparently, antient and very dry workmanship: the other is the celebrated Discobulus. It is known that Myron the Athenian, who flourished about 440 A.C. executed a work of this character in bronze: but we have no evidence respecting the marble statue, and artists have therefore remained in doubt whether it was executed by himself or was a copy by another hand. This question cannot be positively decided by the sculpture itself, however high its merits. In the mean time a step is gained by the mineralogical investigation of the material, and thus mineralogy is capable of throwing light on the history of the arts. The substance in which it is wrought must therefore be considered a sufficient proof of the antiquity of the copy, if it be such, as well as of its having been executed at Athens, since the quarries of Pentelicus were abandoned in consequence of their defects, as soon as those of Carrara and Luna were known. Although it is difficult or impossible to determine this period, yet as so few works in Pentelic marble posterior to the time of Phidias and of Myron have descended to us, it is probable that little use was made of those quarries after the period of these artists. We are therefore, perhaps, entitled to conclude that the Discobulus of the Townley collection is an Athenian work of the best age of sculpture, and not a copy by any more modern artist; and that if it was executed neither by Myron himself nor under his direction, it is yet not likely to have been much inferior to the original, while it may serve, at the same time, as some proof of the esteem in which that work was held at Athens.

But the most numerous examples of Pentelic marble are to be found in those works of Phidias which form the collection of Lord Elgin, and which afford easy access to examination. In the

present corroded and tarnished state of the surfaces of these statues we cannot trace the nature or the defects of this variety, but an examination of its texture and composition in the broken fragments, serves to excite the deepest regret, that the genius of the greatest sculptor whom the world has seen, should for want of better materials have been condemned to bestow its energies on so perishable and so defective a stone. This marble is of a loose texture and moderate sized grain, coarser than that of Carrara, but finer than that of Paros; in colour it is exceedingly imperfect, being tinged with gray, brown, and yellow, and mottled with transparent parts, which give it the appearance of having been stained with oil. But its most formidable defect is its laminated structure, and the quantity of mica with which it is contaminated: to this we are to attribute the corrosion and almost entire ruin of so many of the specimens, the action of the weather dissolving those parts of the stone where the mica is most abundant, and eating deep fissures through many parts of the work. It is peculiarly unfortunate that the two most admirable specimens, specimens which are calculated to excite in the minds of artists a mixed feeling of wonder and despair, the horse's head and the Theseus, should be those which have suffered most. Had they been fortunately executed in the more uniform and durable stone of Carrara, these works might still have been preserved to us in all their original perfection of drawing and surface. Even the hammer of the Turk would have rebounded with little injury from the marbles of this texture, while the micaceous stone of Pentelicus splitting in the direction of its laminæ, has permitted the complete mutilation of many valuable sculptures.

We have no geological information with regard to the relations of these stones. The great resemblance of the Pentelic marble to

that of Glen Tilt in aspect and composition, renders it probable that like this it lies in mica slate, forming beds parallel to and interstratified with that rock: that the others have similar relations to the primary rocks, we should have concluded on general geological principles, had we not already seen that the white marble of Sky which has given rise to this discussion belongs to the secondary strata.

We have now to examine the white marbles which have been discovered in our own islands, for the purpose of comparing their relative properties and the value which they are likely to possess in sculpture. I am unfortunately unable to give any account of those found in Ireland, neither having seen their places, nor being possessed of any specimens.

That which has been found at Cape Wrath in Scotland, is of a grain much larger than even the Parian, and is consequently useless for the purpose of sculpture; and this indeed is by much the most common character of the Scottish specimens. Those of Blairgowrie, of Glenavon, and of Balahulish, are all equally characterized by this large sparry texture, and are all equally unfit for sculpture, however applicable to the purposes of architecture. The marble of Iona has been long since exhausted, and consequently requires no particular notice: however valuable from the purity of its colour and compactness of its texture, yet the uncertainty of its splintery fracture before the chisel, (that tool without which no spirited work was ever finished,) combined with its great hardness would probably have rendered it useless in the arts, even if it were still to be procured.

In a paper on Assynt* I have already described the white marble of that district: it is of a very close texture, and although it con-

* Vol. 2.

tains no earth but lime, is of unusual specific gravity and hardness. It is incapable of being polished, a circumstance, it is true, of no consequence in statuary, since the polish only gives a false light to the surface and is not admitted of in modern sculpture; but it labours under the concomitant disadvantage of want of transparency, producing nearly the same dead effect and dry outline as is seen in a plaster cast, a fault in itself sufficient to prevent it from ever being adopted as a good material in the arts: its extreme hardness also renders it very expensive to work.

The marble of Sky, the more immediate object of this discussion, is of a pure white colour, and appears sufficiently extensive and continuous to be capable of yielding large blocks. The purity of its colour is seldom contaminated; its fracture is granular and splintery, and its texture fine, less fine than that of Iona, but more so than that of Assynt: its compactness, hardness, and gravity, are greater than those of the marble of Carrara, which it in fact resembles in little else than colour. It is apparently well fitted for all purposes of sculpture, as it can be wrought in any direction, and has sufficient transparency, while at the same time it assumes even a better polish than is required for statuary. With these good qualities, however, is combined an uncertainty arising from its unequal hardness. While some parts of the stone are nearly as easy to work as that of Carrara, many other specimens turn out so hard as to add a charge of near 50 per cent. to the cost of working: this appears to arise from the influence of the syenitic and trap veins which traverse it, as I have before mentioned, but which however produce no change in its chemical composition, nor any other effect than that of induration. This addition of price to the current charge of working is sufficient in the harder specimens to counterbalance in a great degree the superior cheapness of the ma-

terial, and the advantages derived from lower freight duty and insurance. Such are the difficulties which oppose the introduction of the most perfect marble which has yet been found in Britain, difficulties which, slight as they are, ought, together with the prevalence of established habits and of a commercial routine, to check the extravagant hopes which have been entertained in this country of superseding by its own produce the importation of foreign statuary marble. But it will not be rendering justice to the marble of Sky if I do not add, that it possesses a property not found in that of Carrara, and one of considerable importance, at least in small sculptures. This is, that compactness of texture by which it resists the bruise which so often takes place in marble at the point where the chisel stops, an effect known to sculptors by the technical term *stunning*, and of which the result is a disagreeable opake white mark, generally in the very place where the deepest shadow is wanted.

I have little to add respecting the marble of Glen Tilt, as I have spoken of it in another place. Except the somewhat larger size of its grain, it is scarcely to be distinguished from the Pentelic: in colour it is precisely similar; but as the character and defects of the Pentelic, which I have already given, are equally applicable to this variety, we may fairly abandon all hope of rendering it useful in the art of sculpture.

II. *On the Oxyd of Uranium, the production of Cornwall, together with a description and series of its Crystalline forms.*

By William Phillips, Member of the Geological Society.

Read February 17th, 1815.

THE only mine in Cornwall which until within the last few years was known to have yielded the oxyd of uranium, was that called Carharack, which was situated about two miles nearly south of St. Die. The crystals on a specimen from that mine in my possession are tabular, of a green colour and transparent, except such of them as are partially or wholly coated by a deposition of an ochreous substance, similar to that termed gossan by the miner. This substance also is interposed between an aggregated quartz tinged with iron, and the crystals; some of which are imbedded in it. It may therefore be termed, in regard to this specimen, the matrix of the crystals. On many of them have been deposited numerous minute cubes of a light green colour; which, as there is a considerable deposition of cubic arseniated iron in a cavity of the same specimen, I consider to be that substance rather than the oxyd of uranium: for though the latter sometimes takes a form so nearly approaching to the cube as that the eye cannot perceive any difference, yet such instances are certainly not very common.

In 1805, I noticed some crystals of the oxyd of uranium on the refuse heaps of Tin Croft mine, which is at the foot of a granitic hill called Carnbrae near Redruth; the veins of that mine run

partly through granite, partly through schist.* A further search enabled me to obtain several beautiful specimens containing many varieties in the form of the crystal as well as in colour. The crystals are for the most part well-defined, but the largest scarcely exceed half a line in length or breadth, and some of them are accompanied by black pecherz (Uran oxydulé Haüy); they were found on, or in the cavities of, considerable blocks of a hard substance enclosing portions of decomposed felspar; but quartz formed the principal part of the mass, which had decidedly the character of being an aggregation resulting from the decomposition of granite. The specimens in my possession, are for the most part thinly coated with a black substance which I consider to be the pecherz in a pulverulent form; internally they are of a redish hue, arising probably from iron, with which the mine abounds, and occasionally some minute rounded portions of iron hæmatites may be observed. The depth at which these blocks were found, according to the best information I could obtain, was about 90 fathoms from the surface, in a copper vein.

I also obtained many specimens containing beautiful and well defined crystals of the oxyd of uranium from Tol Carn mine, which is about two miles north of Carharack, and near St. Die. The veins of Tol Carn mine pass through a decomposed granite, of which the prevailing substance seems to be felspar, enclosing portions of quartz and silvery mica. With this substance the vein seems to have been filled in that part in which the oxyd of uranium was found, but it was of a dark colour, and had attained, though considerably friable, a texture much more firm than that of the neighbouring country; and as, on almost every specimen, the crystals of the oxyd of uranium were accompanied by pecherz,

* Geol. Trans. Vol. 2. p. 152.

it seems probable that both its colour and hardness may be ascribed to the dissemination of that substance throughout the mass, which leaves a black streak on paper. Some specimens also abounded with pyrites both arsenical and martial, and some of them have decomposed since they came into my possession. The veins of Tol Carn mine afforded little or no copper; the uranium was found in one of them at about 30 fathoms from the surface.

The colours of the crystals both from Tol Carn and Tin Croft mines are nearly the same. They vary from almost opake white to yellowish, and pass into the most brilliant yellow; some being transparent, others opake. Of some tabular crystals, the center is transparent and nearly colourless, and the edges are yellow. On other specimens the crystals are transparent and of a greenish hue, whence they pass through almost every shade, into deep grass green; while in others, the center of the crystal is yellow and the edges only are green. Again, from a brownish tinge they pass into a rich brown, but as the surfaces of these crystals glisten, the colour seems to be original; while on many specimens the crystals, which are of a light green colour, are hollow at their centers and of an ochreous brown, a circumstance arising doubtless from decomposition, and which in other specimens has proceeded so far as that the forms of the crystals can no longer be defined.

The crystals on some specimens from Tin Croft mine are accompanied by spiculæ of blue carbonated copper; in others, by green carbonated, and red and black oxides of copper, and on one specimen, they are deposited on minute spiculæ of oxide of iron. I have some specimens of the red oxyd of copper from the mine called Huel Jewel, on which there are very numerous and minute tabular crystals of the oxyd of uranium of a light green colour,

and one specimen of wavellite from Stenna Gwyn near St. Austle, on which some crystals of a light yellow colour are deposited.

But by far the most brilliant specimens of the oxyd of uranium that have been found in this, or perhaps in any other country, were discovered within the last three or four years in Gunnis Lake copper mine near Callington in Cornwall. The gangue of two specimens in my possession is of quartz, bearing the characteristic marks of being the result of decomposed granite, and which is rather confirmed by the circumstance of its cavities being filled with grouan, or decomposed felspar, of a flesh colour; of another specimen, the gangue is wholly a hard gossan. All the crystals from this mine that I have seen are described by fig. 15; they are extremely thin, but on some specimens they are more than half an inch in diameter. They are for the most part lying flat together, forming fasciculi which interrupt each other at various angles, and give an extremely beautiful appearance to the group. In Gunnis Lake mine the oxyd of uranium was found at about 90 fathoms from the surface, and in a part of the vein in which gossan abounded. On the few specimens in my possession from that mine, I have not noticed any trace of pecherz, but on those from Tol Carn and Tin Croft mines, particularly the former, it prevails very much. It is sometimes of a resinous transparency, but is more generally of a dark brown or black, either amorphous or in globules: on several specimens from Tol Carn mine it is quite friable.

It has already been said that the crystals of this substance from Tol Carn and Tin Croft mines, from which the drawings of the accompanying series were made, are for the most part very small; all the larger ones are so deeply striated in a horizontal direction, as

to present the appearance of distinct tabular depositions progressively altering in size; and these are easily separated in the direction of the striæ, by that means discovering occasionally a thin ferruginous deposit between them, but not extending to the edges of the tables. Those crystals which are so small as to merit the term minute, though of a thickness nearly equal to their breadth, particularly those of a deep green colour, rarely exhibit the horizontal striæ on their lateral planes, which are perfectly brilliant: yet I have not been able to find one that could satisfactorily be submitted to the reflecting goniometer. On the measurement of the angles of the oxyd of uranium, it is therefore impossible for me to offer any thing.

The ease with which the crystals of this substance are separated parallel with their terminal faces, was long since noticed by the Abbé Haüy, who adds that its other cleavages can only be perceived by the assistance of a vivid light. The Comte de Bournon who acknowledges much attention to this substance, says (Cat. p. 340) that by the assistance of a strong light, he could perceive indications of cleavages in the directions of both the diagonals of a tetrahedral prism (Fig. 2 or 3), which by both these scientific mineralogists is adopted as the primitive form of the oxyd of uranium. I have very satisfactorily obtained cleavages parallel with the lateral planes of that solid.

The authors above cited do not however agree in regard to the height of the prism which both have assigned as the primitive form of this substance. The former of them has supposed that the height is to the breadth, as 16 to 5, while the Comte de Bournon considers that there is some, though not conclusive evidence for adopting a tetraedral prism with square bases much less in height than that assigned to it by the Abbé Haüy. It is not in my power to offer any thing decisive of this question, for

as it depends, in the first place on the precise admeasurements of certain angles, which no crystal I have hitherto seen has enabled me to make, and in the second place, on calculations founded thereon, for which I possess not the requisite qualifications, I am compelled simply to state the opinions of these crystallographers, and shall be amply gratified if, in their estimation, what is now offered in regard to cleavages not before obtained, and modifications not before noticed, shall tend to throw any light on this important part of the subject.

The occasional notice of what appear to be perfect cubes, added to the certainty that cleavages are practicable parallel with every plane of that solid, at first tempted me to presume that it ought to be considered as the primitive form; but the consideration of some circumstances connected with the crystallization of this substance, induced me wholly to abandon the idea. The inspection of the annexed drawings will evince that, of the five modifications described, the first alone is compatible with the cube.*

All the crystals represented in the accompanying series which are so remarkably flat as to have the appearance of mere laminæ, are from Tol Carn mine, which yielded only such as are of that description, while on the other hand, the greater part of those from Tin Croft mine nearly approach in height the dimension of the cube, or exceed it. A considerable proportion of such as are rather less than that dimension exhibit no striæ on the lateral planes, which are very splendent: many of those which are deeply striated on these planes are iridescent on the surface. The

* In reply to this observation it may be said that the plane which constitutes the third modification of the annexed series, also occurs on cubes of fluate of lime and sulphuret of iron; but on these two substances, which are remarkable for the beauty and elegance of their crystalline forms, that plane only appears in combination with two other similar planes, placed on the edges, and replacing the solid angle of the cube.

crystals from Tol Carn mine are generally of great length and remarkable transparency, those from Tin Croft are more generally opake; but the long and slender crystals from the former mine rarely suffer interruption from each other, being generally deposited at right angles, and thereby shewing a constant tendency to assume a quadrilateral figure.

There are in my possession about 55 specimens of the oxyd of uranium from the various mines in Cornwall above cited, and upwards of 200 detached portions, each having one or more well defined crystals on them and placed on pieces of wax; from these the accompanying drawings were made. Pl. 5, 6, and 7.

Varieties of the Primitive Crystal.

It has been already noticed that the primitive crystal of the oxyd of uranium is considered to be a tetraedral prism, with square bases. I have never observed any crystal, exhibiting the primitive planes only, of a greater elevation than that described by fig. 1. Fig. 4 represents an elongated crystal: this elongation is so considerable on several crystals from Tol Carn mine that the length exceeds the breadth many times.

First Modification.

The first modification is the result of a decrease along the lateral edges of the primitive prism, by which each is replaced by a quadrangular plane.* The crystals represented by figs. 6, 7, and 8, are the most common of the whole series.

* The Count de Bournon in his "Catalogue" has described a modification which I have not been fortunate enough to discover on any crystal from Cornwall, whence every crystal delineated in the annexed series was brought. The planes of this modification he describes as being in combination with that above quoted as the first modification, and as replacing the lateral edges of that plane by quadrangular planes.

Second Modification.

This modification consists in a decrease on the terminal edges of the primitive prism, by which each is replaced by a trapezoidal plane, inclining more on the lateral than on the terminal faces; and, as will be obvious on consulting the planes of this modifications numbered 2. 2, on figs. 23 and 24, tending to produce a very acute octohedron. On the crystals described by figs. 13, 14, 15, and 16, the lateral primitive planes have wholly disappeared. The lines on fig. 9 shew the striæ, which, on the larger crystals, are not only visible, but deep.

Third Modification.

The third modification consists in a decrease on the solid angles of the primitive prism, by which each is replaced by an isosceles triangular plane, inclining more on the lateral edge than on the terminal face, fig. 17. The length of the crystals delineated by figs. 23 and 24, which shew the approach to the acute octohedron, would, if the apices of the crystals had been complete, have equalled at least four times their breadth; they are deeply striated in the direction shewn on fig. 9. I possess a crystal delineated by fig. 24, on which the planes 2.2, are perfectly brilliant and well defined. Fig. 31 shews the combination of the planes of this with those of the preceding modifications and of the primitive prism. On the crystals described by the four last figures in the series of this modification, two of the four planes of the second modification have disappeared on each pyramid, giving to their common base and to their terminal faces the form of triangular planes.

Fourth Modification.

This modification, like the preceding, consists in a decrease on each solid angle of the primitive prism by an isosceles triangular plane, but which, instead of being placed, as in that modification, more on the lateral edges than on the terminal faces, inclines more on the terminal faces than on the lateral edges. On the crystal represented by fig. 42, the planes of this modification are perfectly brilliant.

Fifth Modification.

By this modification the terminal edges of the primitive prism are replaced by trapezoidal planes tending to form an octohedron, fig. 46. The succeeding figure shews the planes of this, in combination with those of the second modification, or the acute octohedron. The crystals described by figs. 46 and 47 are numerous, brilliant, and well defined: they rarely exhibit any lateral striæ, but are so minute as to render it impossible even to approximate the real admeasurement of the angles formed by the meeting of any two of their planes. An attentive examination induces the belief of their being somewhat more obtuse than the regular octohedron; and they are so delineated.

III. *On the Geological Features of the North-eastern Counties of Ireland,*

Extracted from the Notes of J. F. Berger, M.D. M.G.S.

Read April 15th, 1814.

With an Introduction and Remarks,

By the Rev. W. Conybeare, Member of the Geological Society.

Read April 5th, 1816.

INTRODUCTION.

To collect in one point of view the general results deducible from the ensuing detached observations, and enable those who may be unacquainted with Ireland to follow their course with greater facility, it seems desirable to introduce them by a rapid survey of the general features which distinguish the district they refer to.

That district may be described as limited by Dundalk bay on the S.E. and by Lough Foyle on the N.W. including towards the south the counties of Down, Armagh, and the N.E. angle of Lowth lying between Dundalk and Carlingford bay; and on the north, Antrim and Derry: that portion of Tyrone which extends along the S.W. shore of Lough Neagh, between Derry and Armagh, being also comprehended as falling within the same general outline.

This district is marked by three distinct systems or groups of mountains, one of which occupies the more southern counties; while the more northern are divided between the two others.

1st System. The Mourne Mountains.

The Mourne Mountains form a well defined group extending from Dundrum bay to Carlingford bay in the southern extremity of Down.

Slieve Donard is the highest summit of this group; it has been said to rise 3150 feet above the level of the sea, but the estimate of Mr. Templeton,* who assigns only 2590 as the elevation of the highest points of the Mourne Mountains, appears more correct, and nearly agrees with that of Dr. Berger, who calculates its height at 2654 feet.

To the west of the main group the Fathom hills, Slieve Girkin or the Newry Mountains, and Slieve Gullen, all situated in the south-east of Armagh, and the Ravensdale and Carlingford Mountains in the north of Lowth, may be considered as its appendages.

Granite is the prevailing constituent of all these ranges.

To the north of the Mourne Mountains Slieve Croob composed of syenite, and Slieve Anisky of hornblende rock, both situated in the county of Down and barony of Lower Iveagh, constitute an elevated tract dependent upon but placed at some distance from the main group.

Hornblende rock and primitive greenstone are abundant on the skirts of the granitic district. Mica slate has been noticed only in one instance. Exterior chains of transition rocks advance far to the west and north of this primitive tract, extending westwards across Monaghan into Cavan and on the north-east to the southern cape of Belfast Lough and the peninsula of Ardes.

The primitive nucleus bears but a very small proportion in superficial extent to these exterior chains, which are principally occupied by greywacke and greywacke slate.

* Mem. R. I. Academy, vol. 8.

It is highly worthy of observation that the points of the coast of Scotland immediately opposite the Peninsula of Ardes, where the greywacke terminates abruptly on the Irish side of the North Channel, present in the neighbourhood of Port Patrick and through the greater part of the Mull of Galloway, a resumption of the same formation; nor is the analogy in the structure of the two countries confined to this one point. The hills of the Mull of Galloway are a branch of the great chain of mountains which under the name of the Lead hills and other local titles, traverses the whole of Scotland on the south reaching from sea to sea, and the composition of this chain agrees through its entire extent with that of the mountainous tract just described, the transition rocks forming its predominating constituent, enveloped by which several small districts of granite occur, as in the hills of Cairnsmuir and Criffel; while the whole is distinguished from the great northern chain of mountains or Grampians, by the rare occurrence or total absence of mica slate, which in the latter is remarkably prevalent.

On the north of the Mourne Mountains rise the Bann one of the tributary streams of Lough Neagh, and the Lagan which flows into the estuary of Belfast; and on the south several small rivulets which run immediately into the sea, the base of the mountains being in that direction washed by the Irish Channel.

2d System. Primitive Chain of Londonderry.

The mountain group which I have thus designated, rises at the distance of about 30 miles to the N.N.W. of the external chains of the first system.

It forms a large mountainous tract comprehended between the river Roe and the Strabane, partly situated in Derry and partly in Tyrone.

From its southern boundary it emits two water courses; the Mayowla which takes an eastern direction and flows into Lough Neagh; and the Moyle which passes to the west and joins the Strabane river.

On the north the Fanghan waters a beautiful valley, at length discharging itself into Lough Foyle.

Sawell is the highest point of this group: Dr. Berger has fixed its altitude at 2257 feet above the sea. The whole of this extensive and lofty tract is primitive to the very front towards Lough Foyle. Mica slate is the predominating rock, constituting exclusively almost nine-tenths of the district: it is accompanied by primitive limestone in the lower part of the country.

On the eastern bank of the Roe this system of mountains is succeeded by a range of secondary heights, covered by an enormous platform of basalt and forming a part of that system which will in the next place be described. These secondary masses repose upon and conceal the mica slate in the eastern part of Derry, but the mica slate again emerges from beneath this covering, after an interval of near 30 miles, in the N.E. of Antrim, and swells into mountains which break down abruptly towards the coast between Tor Point and Cushenden bay.

The exact correspondence in structure of the opposite points of Ireland and Scotland here again demands our observation; the Mull of Cantire which faces Tor Point resuming the chain of mica slate which was there broken off. The Cantire hills are connected with the Grampians, a chain strikingly similar to that which has been above described in all the circumstances of its composition; and it may be added, as compleating this analogy, that the mica slate of Ireland is succeeded on the south (where the Antrim coast exhibits it in section) by a conglomerate, perfectly resembling that which is so well known as skirting the Grampians on their southern border.

We have therefore strong grounds for believing, without incurring the charge of generalizing too hastily, that the two mountain systems described, should be regarded as prolongations of the great northern and southern chains of Scotland, the former distinguished by the prevalence of mica slate, the latter by that of greywackè.

In the eastern part of Tyrone which intervenes between these two systems of mountainous ground, a coal formation occurs associated with that variety of limestone which is usually found underlying or alternating with the coal measures in Great Britain.

The position of this coal field offers a new analogy with Scotland, where the interval between the southern and northern mountains is principally occupied by a broad zone of rocks connected with the coal formation, upon which are placed those vast overlying masses of trap formation which constitute the Campsie hill, the Ochills, &c. and which, again, correspond both in their constitution and position, with the basaltic group which forms our third system.* Before

* The assertion that the basaltic group of Ireland corresponds in constitution and position with that of the Campsie hills, Ochills, &c. requires perhaps to be stated more distinctly, and more in detail; and in the first place with regard to the correspondence of these districts in the internal constitution of the component rocks. From the description of the Ochills given by Mr. Mackenzie in the 2d volume of the Wernerian Transactions, it appears that the prevailing rock is a variety of floetz trap, possessing characters intermediate between basalt and clinkstone, occasionally exhibiting columns, passing into greenstone, and in places associated with amygdaloid. Beds of claystone porphyry, of felspar porphyry and of compact felspar cap some of these eminences. The Campsie hills have been ably but more generally described by Col. Imrie in the same publication; he represents them as universally covered by a thick mass of floetz trap, divided into beds, partly amorphous and partly columnar. The trap formation of the north of Ireland consists principally of basalt divided into beds, partly amorphous and partly columnar; the latter variety resembles clinkstone in the property whence that rock derives its name; the basalt passes into greenstone, as may be seen in the mountain of Slievemish and other places; and it alternates with amygdaloid. A formation of clay porphyry also occurs in the center of the basaltic area.

In the second place, with regard to the position of the Scotch and the Irish trap districts,

describing that system, it is necessary to observe that another small coal field occurs at Ballycastle, near the edge of the mica slate district in the north-east of Antrim.

there are points of agreement and points of difference: the great features of agreement are those mentioned in the text, namely, that both occur in the vicinity of coal fields, and in a position intermediate between the northern and southern mountain chains. The points of difference are, that the Campsie hills seem, at least along their southern border, to repose immediately on the coal measures; and the same observation may be applied to the junction of the Ochills with the coal field of Clackmananshire at Westertoun. Whereas the basalt of Ireland is generally separated from the coal measures by several intervening beds of considerable importance and of much more recent formation, which appear to be altogether wanting in Scotland. It may be even objected to the instance of Cross hill near Fairhead, which is cited towards the end of this introduction as an example of the occurrence of trap in Antrim under the same conditions with that of Scotland, namely, in contact with the coal measures, that the trap in this instance and through the whole range of Fairhead, assumes a character so widely different from the compact and small grained basalt of the neighbourhood, (being a highly crystalline greenstone) as almost to warrant the suspicion of its being a distinct formation, notwithstanding its close geographical proximity to the great basaltic mass. I confess myself however to be fully persuaded that this suspicion will on further examination be found groundless. The rock in question closely agrees in its texture with that of Slievemish, which it is quite impossible to detach from the general mass of trap. The island of Arran appears to form an important link in the connection I have endeavoured to trace, between the opposite coasts of Ireland and Scotland; the center of this island is occupied by a primitive district, comprising granite, mica slate and syenite; the mica slate extends to and skirts the N.W. coast. The N.E. coast presents a small coal formation precisely analogous to that of Ballycastle, with beds of breccia and of red sandstone resembling those which occur in the Antrim coast near Newtown Glens; this sandstone forms the prevailing substratum through the whole south of the island, where it is covered by a singular columnar clay porphyry, and by greenstone, both of which rocks are generally referred to the floetz trap series. It seems probable that the porphyry which occurs on the opposite coast of Cantire at Devar near Campbelltown, and the syenitic rock which forms the crag of Ailsa may be considered as connected with these formations. The whole island is traversed by numerous dykes of basalt and pitchstone. A similar structure is continued through the corresponding portions of Bute. And an exact resemblance prevails between the northern and southern districts of these islands and the opposite coasts of the estuary of the Clyde in which they are situated; thus the primitive rocks, forming the north of those islands, are resumed on the north of the estuary in Cowal and Cantire; while the sandstone, breccia, and trap rocks of their southern district are continued in that direction through the Cumbray isles, and at Largs and the whole southern bank of the Clyde: the line of junction between these

3d System of Mountains. The Basaltic Group.

This group may be more accurately described as separated into two chains, bounding on the east and west the trough or valley through which the river Bann flows from Lough Neagh to the ocean.

The eastern chain lies in the county of Antrim, being comprehended between the valley of the Bann and the Northern Channel. It presents an abrupt declivity towards the east, falling with a gentle slope towards the west, in which direction the beds composing its mass dip.

The hills of which it is composed are generally detached and distinct, but yet so closely grouped together that there can be no impropriety in considering them as parts of a single chain.

According to Dr. Berger's measurement Kock-lead in the north-

secondary and primitive formations seems to pass near the southern extremity of the Peninsula of Cantire, where a small secondary district, containing, like that of Arran, some indications of coal occurs near Campbelltown. See Jameson Mineral of Scottish isles, vol. 1. p. 134.

Whether any connection can be traced between the floetz trap of Ulster and the extensive deposits of similar rocks in the islands of Sky, Egg and Mull, is a question which will be examined with greater advantage when the geology of these islands has been further elucidated by the able descriptions of Dr. Mac Culloch. It should appear that in these islands strata of shell limestone containing belemnites and ammonites, and appearing to be of more recent formation than those associated with the coal fields of the main land, occur; hence we may perhaps be led to expect that they will be found to exhibit a still nearer approach to the structure of the hills which constitute our third system. Towards the west, the limestones and sandstones associated with the coal formation extend from the banks of Lough Neagh to those of Loch Corrib in Connaught, passing by Lough Erne and Lough Allen; but the overlying trap is confined to the district described in this paper, with one trifling exception which is presented by the Corliew mountains in Roscommon, two miles to the north of Boyle, where the sandstone is covered by a cap of greystone: the structure of these hills, therefore, agrees still more nearly with the trap ranges of Scotland than does that of the great Ulster group.

ern extremity of the chain is the highest summit, it rises 1820 feet above the level of the sea; but the basis of this mountain is occupied to the height of 500 feet by primitive rocks, (connected with that district of mica slate which has been before mentioned as appearing in this part of the country) leaving only 1320 feet for the thickness of the secondary strata peculiar to this system. Diris hill, near the southern extremity of the chain, is wholly composed of those strata and attains an elevation of 1475 feet above the sea: it is situated about two miles to the west of Belfast.

On the S.E. this chain pours several small streams into Belfast Lough, and on the N.E. into the North Channel; all these have a very short course. On the west three rivers of rather more importance take their rise; the six mile water and the river Main which flow into the bay of Antrim in the N.E. angle of Lough Neagh; and the Bush which empties itself into the ocean a little west of the Giants Causeway.

The western chain included between the Roe and the Bann forms the exact counterpart of the former, but the strata here dip in a nearly contrary direction, namely, towards the north-east; the fall of the hills being gradual in this direction, while they front the west and south with abrupt and precipitous escarpments. Cragnashoack at the southern extremity, is as might be expected from this general inclination of the line, the highest summit, it rises 1864 feet above the sea, exceeding by 44 feet the loftiest point of the eastern chain. Slieve Gallion, an insulated hill which stands in an advanced position at some distance from the south bank of Cragnashoack is less elevated by 240 feet.

Benyavenagh, the extreme mountain on the north, is one of the lowest in the chain, rising only 1114 feet.

The Roe, the Clady, and Aghivey, are the principal water courses

this chain sends forth; the two latter are feeders of the Bann, the first empties itself into Lough Foyle.

The geological constitution of this third system is highly important and interesting, it is as has been already observed, wholly secondary and uniformly covered by enormous stratified masses of basalt; this covering appears to acquire its greatest thickness on the north. The basaltic cap of Benyavenagh, the most northern summit of the western chain measuring more than 900 feet; and that of Knock-lead, similarly situated in the eastern chain 980 feet; the average depth of this superstratum may therefore be safely estimated at 545 feet, and its superficial extent at 800 square miles, a solid mass of extraordinary and imposing dimensions.

In the strata underlying the basalt, the English geologist is agreeably surprised to recognise many of the most important of those formations, which reposing upon the coal measures, occupy such an extensive tract in the south and eastern counties of his own island; but which in Ireland are entirely confined to the comparatively small district now under consideration, never extending far beyond the circumference of the great basaltic area; a circumstance which almost naturally leads to the conjecture that they may have been originally much more extensive, but have been elsewhere removed by the agency of some destroying and denuding force, to which in this quarter alone an effectual resistance was opposed by the firm and massive superstratum of basalt which covered and protected them.

The beds alluded to occur in the following order, proceeding from beneath the basalt downwards.

1. Chalk.—This formation, which in England cannot be estimated at less than 800 feet in thickness, does not in Ireland average more than 200. It agrees exactly with the lower beds of the English

chalk, as seen in the Isle of Wight and Isle of Purbeck, which are distinguished from the higher beds of the same formation by their very superior consolidation. It is impossible for any two portions of the same formation to be more entirely identified, by every external character and by the fossils and organic remains contained in them, than are these Irish beds, which have been frequently called white limestone, with the English chalk in the above places: there as in England the lowest beds are destitute of flints which the upper contain in abundance.

2. Mulattoe, an arenaceous stone, with a calcareous cement, of a speckled appearance (whence its name) derived from numerous disseminated spots of green earth. It agrees altogether in its character and fossils with the green sandstone, which occurs in a similar geological position underlying the chalk in England: the thickness of this deposit appears to vary very considerably, and has not in any instance been precisely ascertained.

The numerous beds of coarse calcareous oolites, which in England succeed this green sandstone, are entirely wanting in Ireland, and the mulattoe reposes immediately on the lias limestone. Analogous circumstances are not however wanting in England. In the neighbourhood of Lyme Regis, in Dorsetshire, the green sandstone has extended itself over the outgoings of the oolites, rests upon the lias in a manner similar to that just described; and as it is covered with beds of chalk, the whole section affords an exact counterpart to that presented by the Irish series.

3. Lias Limestone, a blue argillaceous limestone disposed in thin beds, alternating with slate clay, and distinguished by the ammonites, gryphites and the remains of the pentacrinus, which it abundantly contains. It may be worthy of remark that the sections given by Guetard and Monnet in the Atlas Mineralogique de la France, and the accompanying description, clearly prove the

existence of this formation near Metz. Its thickness in Ireland has not been ascertained.

4. The lias in Ireland reposes, as in England, on beds of red and variegated marle, containing gypsum and further distinguished by numerous salt springs; the marle is underlaid by a thick deposit of red and variegated sandstone containing clay galls. These four formations which, together with the basalt, constitute the whole mass of the mountains belonging to the third system, cannot be estimated as possessing a less average thickness than from 800 to 1000 feet: the whole system appears at the north-eastern and south-western extremities to repose upon the coal formation, and its associated limestone, and this again on transition or primitive rocks.

The four formations, more particularly specified, vary considerably in thickness in different places. The mulattoe and lias are often entirely wanting, so that the chalk rests on the sandstone No. 4; this position seems to arise from the superior stratum in such cases extending beyond the outgoings of one or more of the inferior strata, and being thus brought into contact with beds which, when the series is full, occupy a yet lower place.

The chalk and sandstone are however remarkably constant; it may indeed be said to be almost universal within this district; one exception, however, is afforded by Cross hill a little to the west of Fairhead, where the basalt overlies even these, and reposes immediately on the regular coal measures of the Ballycastle district.

The section presented at this point is also worthy of mention, on account of its general resemblance with that of a part of the Campsie hills, published by Col. Imrie in the Wernerian Soc. Trans. Vol. 2. The whole series may be examined with the greatest advantage in the neighbourhood of Belfast, where all its members occur.

The proofs which the deep vallies, separating the detached eminences characteristic of this system, afford of their formation by an agent which has excavated and scooped out as it were portions of the solid strata, have been most ably and clearly detailed by Dr. Richardson in the appendix to the Statistical Survey of Antrim. The general appearances he describes are common (it should be remarked) to the vallies of all countries composed of nearly horizontal strata; but one phenomenon, as stated by him, seems almost peculiar to Antrim, namely, that the materials so removed have been entirely carried off, leaving no traces behind them. This circumstance seems to incline Dr. Richardson to consider the agent which has acted in the manner described, as some unknown and undiscoverable cause, and to hesitate in receiving the common and surely probable opinion which regards diluvial currents as presenting a satisfactory solution; but it must be remembered that the solitary instances he adduces can never weigh against the great majority of cases in which the fragments of the rocks so destroyed not only occur in abundance where they might be expected, but exhibit the most unequivocal marks of their having experienced the action of agitated waters. He who has examined the valley of the Thames from its source downwards can be at no loss for illustrations of these positions, the vast deposits of waterworn debris of oolite which this valley presents where it traverses the range of hills occupied by this rock, and those of flint pebbles where it crosses the chalky hills of the Chilterns, will instantly occur to his mind. It is surely more philosophical to suppose that the violence of the currents has swept away the debris of the Antrim excavations into Lough Neagh on the one side, and into the sea on the other, than that these excavations owe their origin to some unknown cause, distinct from that which appears to have produced all others.

It should be added, that in the county of Londonderry water-worn fragments of basalt really occur in considerable quantity, particularly near the valley of the Roe.

It is impossible to dismiss the subject of denudation without remarking, that appearances analogous to those so forcibly described by Saussure as occurring in the Jura mountains, (where scattered fragments of the alpine rocks attest the subsequent excavation of the great valley now separating the two chains) are also presented, though on a much smaller scale, among the hills we have just examined, where rolled fragments of primitive rocks are often found on the summit of high basaltic ridges, which are at present cut off from all communication with the primitive districts by numerous intervening valleys. (See Sampson's Statistical Account of the County of Londonderry.)

§ 1. *On the Geological Features of the North of Ireland.*

The arrangement adopted in the following observations is, that suggested by the geological position and relations of the rocks described.

I. Primitive Rocks.

A. *Granite.*

- A. Granite.
- B. Gneiss and mica slate.
- C. Primitive limestone.
- D. Primitive trap.
- E. Porphyry.
- F. Syenite.

In the Mourne mountains and adjoining districts an extensive formation of granite occurs, but neither here nor elsewhere in the north of Ireland can we recognize the same varieties of that rock which the mountains of Wicklow present.

The granite now to be described seems rather to agree in its characters with the newer granite of the Wernerians, a rock supposed to be closely allied to syenite. It appears to constitute almost the whole mass of the Mourne mountains, whence it passes across Carlingford-bay into the county of Louth, extending to the summit of the Ravensdale mountains. It soon crosses the limits of Louth to enter into Armagh, composing part of the Faughel hills, whence it expands itself into a flat and elongated ridge, well known under the name of Slieve Gullen, forming likewise the Slieve Girkin or Newry mountains, and the lower and upper Fathom hills, of which the latter keep close to the right bank of the Newry river.

On the north-west side of the Mourne mountains, where they

slope gradually into the plain, the same rock reaches Rathfriland, a table-land of inconsiderable elevation.

Within the geographical boundaries just assigned, the granite is spread over a surface that measures 324 square English miles, comprehending the highest ground in the north of Ireland.

A few masses of other unstratified rocks, of which notice shall be taken elsewhere, occur in this formation.

Some primitive but stratified rocks also rest upon it in many places, generally arriving at their greatest elevations on their south-western boundaries.

The texture of this granite is either porphyritic or finely granular. The felspar always appears the prevailing ingredient, usually grey, more rarely milk white and earthy; the quartz has a smoky tinge, and in the granular variety it generally occurs crystallized in double six-sided pyramids; the mica is of a brown-black colour, and bears but a very small proportion to the other two constituents.

Amongst the accidental ingredients I remarked but two, viz. crystallized hornblende, chiefly abundant in the porphyritic variety, and small redish garnets in the granular. The two varieties are, I believe, mingled both together, so at least they occur on the top of Slieve Donard. I more particularly noticed the granular on Slieve Muck, Slieve Birna, Ravensdale, and Slieve Gullen; the porphyritic on Newry and Fathom mountains. The imbedded crystals of hornblende cause this rock to act on the magnet.

Water-worn pebbles of porphyritic syenite, occasionally containing flesh red crystals of felspar and iron pyrites, are very frequent at the base of the Mourne mountains on the road from Ross Trevor to New Castle. It is probable that these have been derived from the disintegration of neighbouring masses of that rock, occurring

as subordinate beds in this granitic formation; since on the shore at Glass Drummond, a ledge of porphyritic syenite, evidently connected with the granitic mass of the adjoining mountain, is seen running out into the sea.

If the granitic formation, above described, be identified with the newer granite of the Wernerians, it may be conjectured that it reposes on mica slate.

B. *Gneiss,*

Has not been noticed as occurring within the district now described, although the mica slate in the north-east of Antrim sometimes assumes a character which it is not easy to distinguish from that of this rock.

B. 2. *Mica Slate.*

Of all the primitive rocks mica slate appears to be the most widely distributed over the north of Ireland.

In Armagh, the sides of that narrow valley which separates Slieve Gullen from the Slieve Girkin mountains, and contains the small lake of Cum Lough, are principally composed of mica slate.

In the north-eastern angle of Antrim, mica slate forms the prevailing substratum through a district comprising about 40 square English miles, and extending from north-west to south-east, between the mountain of Knocklead (south of Ballycastle) to the valley of the little river of Glendun, which empties itself into the sea at Cushendon, on the north side of Red Bay.

Within this district, however, extensive deposits of very recent

formation (principally chalk and basalt) occur towards the summits of the hills, capping the primitive rock.

The valley of Glendun is formed exclusively of mica slate as far as Done, a village more than five miles inland, here the secondary deposits commence, at the elevation of 590 feet above the sea.

From the mouth of the Glendun river the mica slate extends along the coast, in a northerly direction, as far Murlock Bay, near Fairhead, a distance of about seven English miles; it is here associated with a few other primitive rocks, hereafter to be described. The local name of Cushleak is given to this part of the coast.

Vestiges of mica slate occur on the road from Cushendon to Ballycastle. I have seen it in situ at Ballyvarleys in the bed of a rivulet, skirting the base of Knocklead on the north-east, and have traced it in several other points on the slope of that mountain, particularly at Kileseg, and the low Market hill near Ballycastle. Passing into the county of Londonderry, that great and central mass of mica slate, which from the parallel of the Mayowla river reaches Lough Foyle, extending to the east and west between the Roe and the Moyle, claims our principal attention; it may be computed to cover a surface of at least 476 square English miles of mountainous ground, over which several distinct summits are scattered, including the following, of which I have determined the elevation:—Sawell 2257; Feen Glen 2097; Mullaghash 1677; Moneynieny 1477; Sphell Covagh 1867; and Dunlogan mountain 1467 Feet.

The river Roe, from the neighbourhood of Newtown Limavaddy to its source, may be assigned as the general line of demarcation between this primitive group and the red sandstone which forms the base of the secondary mountains of the third system, (see Introduction): the mica slate is however occasionally seen on both

sides of the channel of the Roe, as is the case at the romantic waterfall called the Dogsleap, near Newton, where a fine natural section of that rock is displayed, and lower down the river in the deer park of Mr. M'Causland; from the district of Tamna Arran near the head of the valley of the Roe, the boundary passes along the Douglas river, a branch of the Mayowla to its confluence: thence it sweeps to the east of the Cairns of Slieve Gallion, and near the confines of Moneymore and Lissane, towards the sources of the Ballinderry river, in the north-east of Tyrone.

A little to the north-east of the source of the Roe, and almost surrounded by the secondary and basaltic ridges of Benbradagh and Cragnashoack, we are surprized at meeting with a small insulated district of mica slate; it forms the entire mass of the mountain of Coolcoscrahan, which rises nearly 1300 feet above the level of the sea.

The characters of the mica slate vary much less than might be expected, considering the extent it occupies in the north of Ireland; upwards of two-thirds of it belong to the talcky variety, the remainder to the common, or that which contains the least quantity of mica and the greatest of quartz.

A circumstance rather remarkable is, that, amongst the multiplicity of specimens I have examined, I do not remember one that contained garnets. How far that extensive formation of mica slate may be metalliferous, it is impossible to say in a country hitherto so little explored.

The subordinate rocks which not unfrequently occur in the mica slate, shall be noticed separately.

C. *Primitive Limestone.*

Primitive limestone exists in several parts of the counties of Antrim and of Londonderry as a subordinate member of the mica slate formation with which it sometimes alternates.

Granular and blue micaceous limestone, with veins of coloured spar, quartz, and green chlorite, occurs on the north-west side of Cairntogher, in the county of Londonderry, at the height of about 800 feet above the level of the sea.

The same granular and micaceous limestone exists in Bennady Glen, and at the old church near Dungiven, at the latter place in large lamellar concretions, passing into compact with a greenish-grey colour: at Banagher church it occurs blue, micaceous, and in small granular concretions. Near Clady, on the road from Dungiven to Londonderry, it is extremely talcky with some quartz nodules; and in the deer park of Mr. M'Causland, near Newtown Limavaddy, it possesses the same character, containing some thin layers of quartz and a few iron pyrites.

Lastly, on the north-east side of Slieve Gallion, there is a primitive limestone which contains crystallized hornblende in abundance: it breaks spontaneously into large rhomboids, incrusted over the natural joints with calcareous spar, of a green-yellowish colour.

At the point of Taur in Antrim, the colour of the limestone varies from grey to reddish grey, and greenish grey; the concretions are rather large, and the texture passes sometimes from granular into compact; it contains only a small quantity of magnetic iron pyrites.

The strata are alternately coarsely and finely slaty: the thickness of the whole mass may be rated at fifty feet. Veins of calcareous spar intervene as seams between the individual strata.

At Toberbilly, on the north-west side of Knocklead, near Ballycastle, at an elevation of four hundred and ninety-four feet above the level of the sea, I traced a bed of granular and micaceous limestone through a considerable extent towards the town-land of Cloughamany.

The concretions are rather small, and there are linings of talc along the seams of stratification.

D. *Primitive Trap.*

The remark of Werner, that primitive trap contains no iron clay, but is wholly or almost entirely composed of hornblende, appears to be extremely appropriate, and to draw an excellent line of demarcation between primitive and the secondary trap.

1. *a. Common Hornblende Rock.*

More than two-thirds of the Foy mountain, near Carlingford, are composed of a succession of stairs formed of primitive trap.

Proceeding from the bottom towards the summit of that moun-

tain, which is 1850 feet high, the trap is seen passing from an homogeneous to a porphyritic texture. The latter imparted by lamellar crystals of felspar of a white colour, and of rather considerable size: gradually the accidental ingredient becomes the essential one; the colour of the felspar becomes greenish, and in that state the rock approaches more nearly perhaps to the character of sienite than to that of trap.

In its genuine state, in the lower part of the mountain, the rock puts on the usual coated appearance which originates from decay.

On the eastern slope of Slieve Birna, one of the Mourne mountains, at one half nearly of its height, I observed a bed of hornblende rock, apparently interposed in the granite.

At Slieve Anisky, a hamlet on the road from Castlewellan to Dromore, I noticed another bed of hornblende rock, but I am doubtful whether it belongs to this class or to that of transition.

b. Hornblende slate.

This subordinate member of the primitive trap series frequently occurs, forming distinct beds, in the mica slate of Antrim and Londonderry.

In the former county it is found in the valley of Glendun, and along the coast from Cushendon to Tor-point.

In the latter it occurs in Bennady-glen, in Aglish-glen, and in the bed of the Roe river near Dungiven. The bed of hornblende-slate in the latter place occupies an extent not less than four hundred yards, ending by the old church, where it runs parallel to a

bed of primitive limestone, before mentioned. It has there a tendency to hornblende rock, while in Bennady-glen it displays a granular texture and a few plates of mica.

2. *Greenstone.*

I have found greenstone in Ravensdale park, at the foot of the mountain of that name, and on the west side of the Faughel hills. I suspect that in those two instances, the latter particularly, it forms beds in the newest granite.

3. *Greenstone slate*

rests against the acclivities of the Mourne mountain, but the strata never rise very high, seldom exceeding 5 or 600 feet; one instance only was observed of a hill exclusively formed of this rock, and that did not attain a greater elevation than about 800 feet.

Attempts have been made to quarry it for roofing slate, and were the works conducted with spirit they might perhaps supply Ireland with as good slate as that now imported from Wales, which appears to belong to the same formation.

The greenstone slate of the Mourne mountains contains apparently no crystallized hornblende in the basis, though it is disseminated through the latter, as is shewn by the manner in which it fuses before the blowpipe. I have remarked in it some crystals

of glassy actynolite passing into hornblende, veins of quartz, magnetic and common iron pyrites. The basis sometimes approaches in its nature to clay-slate.

4. *Hornblende with Mica.*

This aggregate rock composes the top of Clark's hill or Slievesleet, five hundred and forty-eight feet above Castlewellan. I also noticed it on Slieve Croob, between Slieve Nasky and Bakaderry town. I saw it again in loose blocks about Castlewellan.

A Druidical monument at Coagh near Cookstown, is partly made of an aggregate of crystals of hornblende. The same compound I observed, but not in *situ*, at the basis of the mountain of Coolcoserahan.

E. *Porphyry.**

Felspar porphyry occurs in the county of Down, in the bed of the Finish, on the north-west side of Slieve Croob, near Drummara in the lower Iveagh; and in a decomposing state at Ballyroany, four or five English miles north-east of Rathfriland. In the first of these localities it is interposed in a compound rock of granular quartz and mica.

* See the article on some porphyries of doubtful formation at the end of these extracts.

In the mica slate district of Antrim, several beds of felspar porphyry are found; they may be traced along the coast from Torpoint to Cushendon, and thence inland along the old road to Ballycastle.

In Londonderry, the fundamental rock on the east side of Slieve Gallion is a variety of felspar porphyry strongly resembling sienite, with which rock it probably alternates in this mountain.

In the same neighbourhood felspar porphyry may be traced without interruption from the top of the glen of Latterane to the bed of the Knockadoo river on the road from Lissane to Moneymore.

F. *Sienite.*

I have traced this rock in the low country adjoining the town of Newry for three or four miles on the road to Dundalk, for the same space on that to Armagh, and towards Bainbridge as far nearly as the four mile house. It is perhaps more extensive.

The sienite is unstratified, cropping out in independent mases, but rent into pieces mostly of a rhombic figure, the natural joints of which are generally rusty.

It is finely granular, composed of felspar of a blood red, flesh red, or greyish colour, with some quartz, hornblende, and black mica, besides two ingredients, accidental but not uncommon, namely, iron pyrites and small garnets.

The sienite that crowns the summit of Foy mountain near Carlingford, contains only a few broad plates of black mica, with greenish felspar and hornblende in large concretions.

Slieve Croob in the lower Iveagh, the most conspicuous hill of a small group that lies nine miles in advance to the north of the Mourne mountains, seems formed on its north-east and south-east sides of different varieties of sienite, some of which are porphyritic and very beautiful: the crystals of hornblende are extremely well defined, and the compact felspar constituting the basis has a brownish or smoky colour.

This sienite crops out at intervals from Bakaderry town to the top of Slieve Croob, occupying an elevation of about 900 feet.

Slieve Gallion, in Derry, exhibits sienite in connection with porphyry, and either of a porphyritic texture or in large concretions; I met with an elegant variety on the road from Lissane to Lough Finca; the felspar is either slightly green or flesh-red with hornblende, quartz, and some pyrites. This rock acts strongly on the magnet.

In the bed of the Black-water near the valley of the Mayowla, on the north-west side of Slieve Gallion, the sienite is mostly composed of crystallized hornblende with some felspar and iron pyrites, verging therefore into greenstone.

II. TRANSITION ROCKS.*

A. Greywacke.
B. Transition limestone.
C. Transition trap.
D. Old red sandstone.

A. *Greywacke and Greywacke Slate*

occupies a great part of the baronies of Ardes, Castlereagh, and the two Iveaghs in the north of the county of Down, whence they extend through Armagh and Monaghan into Cavan. The accompanying map (Pl. 8.) will convey a sufficiently accurate idea of their extent. Their characters do not differ from those which they exhibit in other countries already frequently described.

The greywacke slate is worked extensively for roofing slate at Ballyalwood in the center of the peninsula of Ardes: a variety however, still better adapted to this purpose, remains yet neglected at Cairn Garva, on the west-south-west of Conbigg hill.

At Cultra, on the north-east of Belfast lough, flinty slate and drawing slate occur as subordinate formations in the greywacke.

Lead and copper ores have been found in this formation at Conbigg hill, between Newtown Ards, and Bangor, and I believe at some other places. A mine was formerly worked at Conbigg, but is now abandoned.

* The term transition is here employed merely as the name of a class of rocks intervening in their position and intermediate in their character between the primitive and secondary classes, no other or hypothetical meaning is attached to it. The old red sandstone here described, has been associated with these rather than with the secondary rocks, because it appears in one instance at least to alternate with greywacke.

B. *Transition Limestone.*

The entrance of the noble bay of Carlingford is bounded on the south-west side by an obtuse point of land very low, and almost on a dead level, whence the Foy mountain boldly rises, falling away to the south towards Cooley, where it forms the ridge named Golding mountain.

The greater part of this flat point of land, ending on the north at Carlingford Castle, is occupied by a limestone formation which I am disposed to refer to that of transition.

It covers a square surface of about nine English miles, reappearing at the Block-house island in the middle of the bay, but I am not aware that there are any vestiges of it on the shore in the county of Down, which limits the north-east side of the bay.

The strata lean on the east side of the Golding mountain dipping to the south east: they however rise to a very inconsiderable height upon its abrupt declivity.

There are quarries opened in a continual line to the extent nearly of one English mile, at the foot of the Golding mountain, the depth of the quarries varying from fifty to eighty feet: limestone is raised besides in other places nearer to the shore, at Cooley, Mullaghtre, and the Gan rocks.

This limestone is remarkable, because it alternates both with transition trap and with greywacke slate; evidently so with the former at Cooley, and with the latter at the Gan rocks.

The solid strata are frequently traversed by veins and thin layers of calcareous spar: between them intervene many thinner beds passing into slaty marl.

The limestone itself somewhat varies in its characters at the different places where it occurs. In point of colour it passes from bluish-black to smoke-grey: the first variety is more compact, the lamellar concretions less evident, and it is sometimes traversed by veins of flinty slate; small quartz concretions are occasionally though rarely interspersed in it. I have seen in it crystallized iron pyrites: it contains superficial impressions of cornua ammonis, covered with iron pyrites; madrepores, both ramose and columnar; nautili figured by Walcott, (Bath fossils fig. 44.)

Two small limestone districts occur near the shores of Strangford Lough, one at Lisbawn near Down Patrick on the south-west, and the other near Cumber on the north-west; the latter appears to be of the magnesian variety; orthoceratites have been noticed in it.

It has not been ascertained to what formation these limestones belong, but since they occur in a district where greywacke prevails, they may with greater propriety be noticed here than under any other article.

C. *Transition Trap.*

The formation of greenstone which alternates with the limestone at Carlingford has invariably a crystalline texture, but differs in its other characters in presenting the following varieties.

1. Common greenstone.
2. Close grained and porphyritic.
3. Approaching to greystone.

The beds are three or four feet thick.

On the east side of Slieve Gallion at the head of a narrow glen called Tinteagh Glen, about 1300 feet above the level of the sea, crop out several unconnected masses of greenstone.

They are totally unconnected with the flat stratified trap which overlies the chalk, and crowns the summit of the mountain. The fissures are lined with calcareous spar, and veins of crystallized heavy spar and of red compact iron stone are contained in this rock.

D. *Old Red Sandstone.*

This formation has been observed only in the two following districts, and even there its extent appeared to be very limited.

1. In the county of Down, on the sides of Strangford lough.

2. On the N.E. coast of Antrim, between the bays of Cushendall and Cushendon; and again in Murloch bay.

Vestiges indicative of the old sandstone may also be traced along part of the shore of the Isle of Rathlin opposite Fairhead.

The tract of sandstone first specified extends from the E.N.E. side of Strangford lough to Scabro hill on the opposite side of that lough, appearing likewise at Ballymasca, Dunlady, and Kirkdonnel.

Scabro hill rises 483 feet above Strangford lough, its summit is composed of a cap of greenstone about 150 feet in thickness; the remaining 330 consist principally of the sandstone, which may be observed in one* of the quarries opened on that hill (to procure this material for architectural purposes) in distinct beds of very variable thickness alternating with greywacke.

* The name of this quarry is the White quarry

The colour of this sandstone is reddish or greyish; its texture is either conglomerate, including fragments of greywacke slate, or finely granular, composed of quartzose grains imbedded in a cement, sometimes calcareous and sometimes siliceous. The greenstone which caps this hill differs very slightly from that associated with the floetz trap.

Lord Londonderry has caused this formation to be bored to the depth of 500 feet in the fruitless search for coal on the east side of Strangford lough near Mount Stewart; if to this depth the height of the sandstone on Scabro hill be added, it will give from 800 to 900 feet as the known thickness of this formation. The greatest length of this district of sandstone does not exceed six or seven English miles. It appears to rest upon greywacke.*

The tract of this formation between the bays of Cushendall and Cushendon, is yet more limited than the preceding. On the coast it occupies a line of between three and four English miles, and extends about the same distance in an inland direction. The highest point of the cliffs on the coast in this range is only 124 feet; but the hill of which they form the escarpment rises at Jeaveragh near Cushendall church to the height of 522 feet: this is the greatest elevation which the sandstone of this district attains.

The strata dip into the sea towards the E.S.E. under an angle of about 32°. In the bay of Cushendon several caverns of considerable magnitude occur in this rock.

The general character of this formation is that of a conglomerate; it passes however into a coarsely granular texture, and in one place (the Red bay of Cushendall) into a finely granular: its colours vary from red to grey.

* The arrangement of the sandstone formations in the north-east counties of Ireland, forms the most difficult problem presented by their geological relations. The sandstone

The conglomerate contains in great abundance large pebbles of quartz, and more rarely of hornstone porphyry; also of a rock which appears to have been a greenstone porphyry, but is much altered by decay; and lastly of mica slate. The coarsely granular variety consists of quartzose concretions imbedded in an argillo-calcareous cement.

This sandstone formation appears to rest on the mica slate which succeeds it on the north side of Cushendon bay, and occupies the district of Cushleak described in a former article. At the opposite or N.W. extremity of that district we may again trace the sandstone in Murloch bay: it there appears very distinctly on the beach near the great Whin dyke, in its conglomerate form.

To the westward of Church bay in the Isle of Rathlin, and near a spot called the Black rock, I found fragments of the old sandstone associated with blocks of syenite in such abundance as to impress me with a strong belief of the former existence of both these rocks

of Lough Strangford with its cap of greenstone presents so obvious an analogy to the structure of Cragnashoack at the southern extremity of the floetz trap chain in Londonderry, that we might be almost tempted to infer the identity of the sandstone in both instances, and, since that of Cragnashoack is certainly the newer variety, to question the propriety of assigning to that of Scabro hill the antiquity which has been claimed for it in the text: its apparent connection with the sandstone of Belfast lough, also seems to favor the idea of its belonging to the newer variety, for in travelling between Belfast and Newtown Ards, the road is said not to exhibit any rock but sandstone, in situ, although hills of greywacke rise within a small distance on either side: yet the fact mentioned by Dr. Berger of the alternation of this sandstone with greywacke, seems decisive as to its age.

The sandstone of Cushendon also appears to require further examination: one of the most interesting facts concerning it appears to have escaped Dr. Berger's notice, namely, its connection with a formation of reddish clay porphyry. The observations made by Mr. Buckland and myself on this formation will be found in the account of the sections presented by the coast, appended to these extracts. It is only mentioned at present as affording an analogy between the sandstone which skirts the mica slate of Cushleak, and which occurs in a similar situation in the island of Arran.

in that direction. Were the sea to retire a few fathoms and disclose the foundations of Rathlin, we should very probably discover the trap which constitutes the present surface of that island, resting on the old sandstone; and that rock in its turn reposing upon syenite.

III. FLOETZ ROCKS.

A. Limestone underlying the Coal formation.
B. Coal formations.
C. Sandstone formations.
D. Lias.
E. Green Sandstone or Mulattoe.
F. Chalk.

A. *Limestone* underlying or associated with the Coal Formation.*

At the entrance of Cookstown on the road from Coagh, there are quarries of a shell limestone formation supposed to extend itself to the south as far as to Steward's town, and nearly for one mile in the other directions: it is disposed in strata alternately

* The limestone here described appears to constitute a portion of that great limestone formation which may be traced through the counties of Kilkenny, Kildare, Dublin, the Meaths, Roscommon, the south-east of Mayo, Sligo and Fermanagh. The great coal districts of Kilkenny in the south, and of Lough Allen in the north, repose upon it; as also do those of Dungannon and Coal Island described in the next article.

The points described in the text are principally situated on the north-west of the coal formations last mentioned, and near the line separating the sandstone associated with the coal, from the primitive mountains connected with the great chain of Londonderry.

solid and compact, earthy and marly which vary from one to three feet in thickness, and dip north-west at an angle of about 27°. The texture of this limestone is compact, though composed of distinct lamellar concretions: it is traversed by veins of calc spar of a reddish colour, and is soluble in acids without residuum: the specific gravity is 2.84. It is used for building; and the mortar made from it is said to be considerably stronger than that of the newer white limestone. It contains organic remains.

At Desartmartin in the county of Derry, ten miles to the north by east of Cookstown, there is a similar shell limestone of a smoke grey colour, which is also quarried. The strata dip north west at an angle of eight degrees. They contain two sorts of terebratulites, namely, *terebratula gigantea* and *terebratula producta*, and imbedded nodules of a glassy quartz sometimes of the size of an hazel nut, a circumstance that renders the blasting of this limestone with gunpowder attended with danger. I was informed that at the depth of seven yards, the bed of limestone is exhausted and reposes on a stratum of clay, but I had no opportunity of ascertaining the fact myself.

On the south of these coal districts the limestone is yet more extensively displayed, intervening between them and the northern boundary of the greywacke district in Armagh: it is here exhibited skirting the banks of the river Blackwater above Charlemont for several miles; and the country on the south and south-east between Charlemont, Loughgall, Kilmore and Armagh, is principally occupied by this limestone. On the east of this district near Hillsborough and Lisburn, it seems probable that the sandstone and greywacke come into contact, the limestone being wanting: but still farther in the same direction, at Cultra and Holywood, on the southern shore near the middle of Belfast Lough, the limestone again appears in a position intermediate between the sandstone and greywacke, but probably not in immediate contact with the latter, a red sandstone of older formation being said to occur in the interval. This limestone is of the magnesian variety, (which also occurs in the same formation near Dublin) its texture compact, but not crystalline, its fracture granular, its colour ochre yellow; it contains cavities lined with calc spar, and presents organic remains: the thickness of the beds varies from one to six feet.

The shell limestone of Desartmartin re-appears two miles farther to the north-east at Dromore, the strata preserving the same dip, direction and characters: the quarries of Dromore are more extensive than those of Desartmartin.

At Gore Tarminey in the parish of Kilcrouaghan not far from Dromore, the shell limestone shows itself again, but under the character of swinestone: it is variegated, and contains terebratula gigantea. The strata dip at an angle of 12°.

At the coal works of Ballycastle two English miles north of the town, strata of shell limestone are to be seen on the shore, and may be traced at low water running out to sea in their line of bearing, which is N.E. 17°. they dip therefore to S.E. 73°.

The strata are alternately solid and marly, the former constituting beds of three or four feet in thickness, the latter not exceeding half a foot. The solid strata are of a compact limestone with lamellar and rhombic concretions, the colour smoke grey.

I have examined several specimens of a variety of this limestone containing ramose madrepores, said to have been found on the west side of Lough Neagh in Tyrone.

B. *Coal Formations.*

I have to notice four partial coal formations: they occur in the following counties.

I. Tyrone: at Coal-island and Dungannon.
II. Antrim: near Ballycastle.

1. Two *Coal fields*, as coal formations are usually styled in England, exist in the county of Tyrone, at no great distance the

one from the other, viz. at Coal island and Dungannon; with the latter I am totally unacquainted: it is I believe, by far the most extensive of the two: whether they may be considered as connected and thus constituting but one single formation, I do not pretend to say.

The coal formation of Coal island is in an open part of the country, though with a gently waved surface. The whole extent of the coal district or *Pound*, as it is called, does not exceed as I was informed, four hundred yards square.

The works in this district appear to have been prosecuted formerly with more activity than at the present period, some of the pits being now abandoned; several however still remain, but they seem to be conducted with little of capital or of spirit. The steam engine has not yet been introduced; the power of horses only is employed to raise both coals and water, which last is unfortunately very abundant. In one pit called the Mary Anne, which I visited, 150 barrels were computed to be drawn out every day. None of the pits (so far as I was informed) exceed 75 yards in depth: the quantity of coals raised daily in the Mary Ann pit amounted to thirteen tons, though no more than thirty colliers were employed. The coals are said not to cake, they are applicable to all domestic purposes, and are I believe mostly consumed by the inhabitants of the adjacent part of the country, notwithstanding a bounty allowed by government to send them either to Newry, Belfast, or Dublin.

Several seams of coal occur, the main bed is nearly six feet in thickness; its general direction is north-west and south-east: the dip of the strata is here towards south-west. At Dungannon, as I was informed, this direction becomes reversed.

2. The collieries of Ballycastle occupy an extent of less than one English mile along the coast. They have been long wrought, and were once in a more flourishing state than they are now: they formerly used to send from ten to fifteen thousand tons of coal to the market yearly, whereas the ground bailiff with whom I conversed several times, assured me that the quantity now exported did not amount to more than fifteen hundred or two thousand tons.

Owing to prejudice, I believe, rather than to greater expence, the country people prefer burning turf rather than coals, and even the inhabitants of the Isle of Rathlin, who have but a very spare quantity of that combustible, come to the Main to carry it over instead of coals, though ultimately it must be more expensive and surely more troublesome.

The Ballycastle coals are therefore sent to Dublin, chiefly on board the numerous trading vessels bound to that port from Londonderry, which thus instead of going thither in ballast, take a freight of coal on their passage. The Irish coals in Dublin receive a bounty equal to the duty laid upon the English coals.

There are but four coal works now wrought out of twelve which were formerly opened near Ballycastle: Gob colliery is the most extensive and advantageous.

As the beds of coal crop out a few feet above the level of the sea, there is no occasion for sinking shafts, but some of the horizontal galleries are of great extent; that of Gob colliery into which I went, is not less than eight hundred and twenty yards: they have a considerable quantity of water, and, which is worse, they suffer so much from foul air that the colliers cannot stay more than eight hours out of twenty-four in the mine. The beds dip to the south-east about one foot in nine.

I should apprehend that this partial and broken formation is mostly exhausted.

It may not be improper to subjoin here the series of the *rock-measures* at two or three of the collieries which I visited in the north of Ireland. I shall first give the provincial names, adding the scientific terms which appear to correspond to them.

ROCK-MEASURES OF THE MARY ANN PIT,

IN THE COUNTY OF TYRONE,

from the surface downwards.

	PROVINCIAL TERMS.	GEOGNOSTIC NAMES.	FEET.	INCHES.
1	Sandstone		33	
2	White-metal	Grey-white clay Ironstone	4	
3	Slate	Slate-clay	2	
4	Craw-coal	Slate-coal	1	6
5	Turbage	Soft slate-clay	3	
6	Grey-metal	Reddish brown clay iron-st.	21	
7	Slate	Slate-clay	1	6
8	Bone-coal		2	4
9	Turbage	as above	4	
10	Grey Bind		9	
11	Black-measure	like Sand?	9	
12	Grey-metal		6	
13	Slate	Slate-clay	2	
14	Main Seam of Coal		5 to 6	
		Total - -	104	4

This account of rock-measures falls short of the depth of the pit itself, by seventy six feet; and we must either suppose that some of them recur once or twice more in the series, or rather that it is not perfectly correct: my authorities in this and the following table were the miners who attended me as guides.

ROCK-MEASURES OF LUGG-GLASS* *(The Green-Hollow.)*

COLLIERY AT BALLY-CASTLE IN THE COUNTY OF ANTRIM,

from below upwards.

	PROVINCIAL TERMS.	GEOGNOSTIC NAMES.	FEET.	INCHES.
1	Hard-rock	Sandstone.....	33	
2	Till	Slate-clay.....	2	6
3	Rock	Sandstone, probably	33	
4	Main Till	Main bed of Slate-clay ..	18	
5	Coal	Slate Coal.....	4	6
6	Rock.....	Rock.....	33	
		Total - -	124	0

The preceding tables evince the general resemblance which the members of these coal formations bear to those of other countries. It is necessary to add very few remarks.

The coal of these districts is almost entirely slate coal; it may perhaps be suggested as a general observation concerning the Irish

* The above section relates only to the beds contiguous to the coal now worked. Sections of the entire cliff have been given by Mr. Whitehurst in his Theory of the Earth, page 260, and by Mr. Dubordieu in the Statistical Survey of Antrim; but it is impossible to reconcile the one to the other. From the hasty survey which I was myself able to take of this spot, I can only furnish the following particulars :—

The total height of Cross Hill, in the north face of which the collieries are worked, is about 500 feet, of this elevation about 150 feet is formed by a cap of columnar green-stone, which reposes on alternating strata of sandstone and slate-clay, these extend about 150 feet in depth, and cover the bed of coal in which the workings are situated, and which occurs at an elevation of about 200 feet above the beach; below it are other strata of slate-clay, with perhaps some seams of imperfect coal and sandstone, and we particularly observed beds of the latter rock, of an intensely red colour and of enormous thickness: lastly, strata of limestone are seen emerging from the sea towards the west of the collieries; the interval between the coal and the limestone is much concealed by slopes of debris, covered with an imperfect vegetation, which rest against the base of the cliff.

An opinion is prevalent among some of the miners, that a thicker stratum of coal than that at present in working would be found by driving adits beneath the level of the sea.

coal formations, that supposing a line drawn across the Island in the parallel of Lough Allen from east to west, the coal found to the north of that line is principally slate-coal, and that on the south cannel coal. In one of the works, however, in Coal Island, a bed of cannel coal six feet thick is said to have been wrought.

The slate clay at Mary Ann Pit contains impressions of aquatic plants, vegetable impressions similar to those of the Derbyshire collieries have also been observed in the Ballycastle district.

Clay ironstone occurs both in nodules and beds, and brown spar passing into sparry iron ore has been observed at the coal works of Ballycastle, where it forms a bed of some thickness traversing the cliff at a little depth below the principal seam of coal.

A bed of trap lying in a conformable position between the strata of sand, occurs a little to the eastward of the coal works of Ballycastle, between Fairhead and the little Glen of Port-na-crea, along the Crag of Sron Găl or of the " White-nose."

This geognostic fact, the only one of the kind I have seen or heard of in the north of Ireland, was pointed out to me by the ground bailiff of the collieries, who called it a *horizontal dyke.*

Its thickness is about two feet. It has a slaty structure, and is micaceous where it lies immediately in contact with the sandstone, the usual characters of which appear altogether unaltered. It breaks spontaneously into forms resembling triangular pyramids; the texture is remarkably close, it is almost entirely formed of finely crystallized hornblende, with some thin scaly parts of white felspar: it acts on the magnet, and yields a black enamel before the blowpipe.

* Several vertical dykes also occur traversing the coal measures near Ballycastle, these will be particularly described in the account of sections on the coast.

C. *Sandstone Formations.*

On the skirts of that elevated district in the county of Antrim and in the eastern division of Londonderry, which is occupied by the more recent flœtz rocks (namely lias, green sand and chalk, surmounted by a vast cap of basalt) extensive deposits of sandstone occur, forming the basis on which this lofty platform appears to repose.

These deposits of sandstone appear therefore to be in every instance of greater antiquity than the lias which they support, they seem also to be partly coeval with and partly more recent than the formations already described, as they are seen either alternating with or overlying the members of those formations where they can be traced in connexion with them.

They may be considered as identified partly with the coal sandstones of England, and partly with the formation here known by the name of red rock marle, the lower beds of these deposits being referable to the former class of rocks and the higher which contain gypsum to the latter; to ascertain however the precise demarcation of these subdivisions is a task for which materials are as yet wanting.

A further difficulty occurs in two instances, namely, at Cushendall bay and at Murloch bay, where these deposits are brought apparently into contact with the old red sandstone, without the intervention of the coal measures or their associated limestone, so that it is hardly possible to assign the points at which the old sandstone terminates, and is succeeded by these younger members of the same family.

The sandstones intended to be described in the following article, occupy the following localities.

1. The valley of the river Lagan from Moira to Belfast, and the north-west shore of Belfast Lough as far as the Peninsula of Magee.

2. Several points on the north-east coast of Antrim.

3. A line in the eastern division of Derry and north east of Tyrone, extending from the mouth of the river Roe to the south west extremity of Lough Neagh.

1. Sandstone of the valley of the Lagan and Belfast Lough.*

The sandstone formation may be traced from the south west extremity of the county of Antrim, where it joins that of Down, occurring between Moira and Lisburn, at Maheramesk, Spencer's bridge and Maheragall; it proceeds along the valley of the Lagan, extending into that of the Forth, a small river which becomes tributary to the Lagan near Belfast; from that town it occupies the road to Carrickfergus, whence it ascends the valley of the Woodburn, another brook discharging itself into Belfast Lough; it afterwards extends as far as Castle Chichester, in the island of Magee.

The prevailing colours of this sandstone are various shades of red and reddish brown, but it is variegated by many coloured stripes; it contains clay-galls; its texture is friable; the cement is calcareous; spangles of mica constantly occur.

At Carrickfergus, where the rock is more than usually adherent, it is raised for flags.

The upper members of this formation become argillaceous, consisting of beds of reddish brown marle, alternating with a greenish slaty marle, and an indurated grey calcareous marle; these may be

* On the opposite side of Belfast Lough this sandstone extends towards Holwood, where it rests upon the limestone before described, and we traced it for some distance on the road from Belfast to Newton onwards.

seen at Maheramesk near Moira, in the valley of the Forth near Belfast, in the valley of the Woodburn, near Carrickfergus, and at Castle Chichester in the island of Magee. In all these localities, veins of a delicately white fibrous gypsum occur: salt springs, the usual accompaniment of similar strata, are found near Carrickfergus, and in other places.

The sandstone has been sunk into near Lisburn nearly 200 feet without reaching its inferior extremity, and the red marl which overlies it near Belfast is estimated as varying from 40 to 100 feet in thickness.

The outgoings of the sandstone strata are low, they dip towards the hills on the north west.

2. Sandstone on the east and north east coast of Antrim.

The same sandstone which has thus been traced as far as the head of Larne Lough, may thence be pursued in various points on this coast, but since its superior edge is often depressed below the level of the sea, and on the other hand its inferior edge is in one instance elevated far above that level resigning the coast to formations of greater antiquity, it presents in this part of its course an irregular and broken line, of which the description will be the more readily followed if postponed to the explanatory notes on the section of that part of the coast subjoined to this paper.

3. Sandstone in the east of Derry.

The variegated marle which covers the sandstone, first makes its appearance, rising from the level of the sea, a little to the west of Downhill near the mouth of the Roe, thence it passes to the south west, bassetting along the base of the bold headland of Macgilligan, and of Benyavenagh the most northerly mountain of the secondary chain in Londonderry. At Kedy hill the next of the groupe, the sandstone, which continues ascending towards the south west,

attains the elevation of 450 feet above the sea; in the adjoining mountain called Donald's hill, its upper limit rises to 900 feet; it occupies nearly the same level in Benbradagh, and at Cragnashoack the southern point of the chain gains its greatest height, being there 1589 feet above the sea. In this mountain the sandstone and basalt are in contact, the chalk being deficient. Cragnashoack and Fairhead are, it is believed, the only instances in this district where the trap is seen decidedly reposing on any other rock than the chalk.

The sandstone of Benyavenagh, of Kedy and of Donald hill, is red, slightly variegated with yellowish stripes of a rather loose texture; it has a calcareous cement, and contains specks of mica.

The sandstone of Benbradagh has the character of sandstone slate, the texture coarsely granular; colour greenish white; with a calcareous cement, and containing spangles of mica. It extends to Dungiven, and probably reposes on the mica slate, which occupies the left bank of the Roe; its thickness in this hill cannot be less than five hundred feet. About a quarter of a mile from Dungiven, at the opening of Benady glen a sandstone conglomerate occurs, probably connected with this formation.

The insulated primitive district of Coolcroscrahan, which is situated behind Benbradagh on the north east, appears to be encircled with a ring of sandstone and marle.

In Cragnashoack, two varieties of sandstone may be traced, the upper beds consisting of a coarse grey sandstone with a calcareous cement, while the lower strata are more distinctly slaty and micaceous, and have a yellowish colour and a siliceous cement.

From Cragnashoack the sandstone extends to the south, abutting on the north east slope of Slieve Gallion. Near this point it appears to repose upon the shell limestone of Desert Martin, ranging from

thence by Moneymore towards Lissane; on the Canesee river, a small brook which is crossed in passing between the two last mentioned villages, strata of sandstone conglomerate are found.

Near Cookstown, grey sandstone passing into white occurs on the road to Dungannon, it extends beyond the bridge over the Blackwater river, the outgoings of the strata rise south-west 43° under an angle of 8°. There are other sandstone quarries one mile and a half from Cookstown towards Moneymore; a red variety is here found, it is finely granular, with a calcareous cement, the strata crop out south-west 53°, at an angle which varies from 13° to 25° as they increase in depth.

At Coal island, in the county of Tyrone, sandstone constitutes the superficial stratum, two varieties may there be distinguished, both however agreeing in having a siliceous cement; the one is hard, coherent, and finely granular, of a yellowish grey tinge, with spangles of bright mica abundantly disseminated; the other is characterised by a looser and coarser texture, an inferior specific gravity, and fewer spangles of mica.

D. *Lias.*

[This article is applied by the Editor from the joint observations of Mr. Buckland and himself, the route pursued by Dr. Berger, not having allowed him to examine this formation in the points which exhibit it to the greatest advantage.]

This formation consists of beds of slate clay alternating with thin seams of argillaceous limestone; the limestone is compact but not crystalline, of a bluish colour passing into smoke grey; the fossils which characterise it are cornua ammonis, gryphites, and the colum-

nar joints of the pentacrinus; this formation may be studied most advantageously along the line of coast between Gerron point and Lough Larne, on the east side of Antrim, where several sections of it are exhibited. On the south of Gerron point the extensive bay of Glenarm opens; the village of Glenarm itself is situated near the south cape of the bay, between two lofty hills of chalk covered with basalt; the range with which these are connected sweeps in a bold semicircle round the bay, receding considerably from the line of coast which generally presents only a flat beach; towards the centre of the bay, however, a low crag of red sandstone occurs, distinguished by the name of the red braes of Carnallock; half way between these and Glenarm, the clay of the lias formation may be traced, interposed between the red sand and the green sand which underlies the chalk.

But this formation is far better displayed after doubling the Cape of Glenarm in the cliffs beneath the deer park, about two miles south-east from that village; here it emerges from under the chalk and green sand, and exhibits a thickness exceeding 100 feet. Near the outlet of Lough Larne lias has been traced in Port Muck, at the north-east extremity of the island of Magee, and borings, engaged in from the hopeless speculation of discovering coal, have proved its existence among the substrata in other parts of that island, where it rests on red marle containing gypsum. On the western shore of Lough Larne, lias occurs about one mile south from the town whence the lough derives its name; it skirts the margin of the lough for some distance towards the south, but does not appear to rise many feet above high water mark. Only one thin stratum of the limestone is here visible; this contains gryphites and pentacrinites.

We understood that lias had been traced in several places between Larne and Belfast. In Colin Glen, about four miles south-

south-west of that town, the mulattoe rests on a slate clay probably of this formation.

The localities already cited range along the south eastern border of the great basaltic and secondary area; the same formation appears also to exist towards the northern boundary. From specimens which we examined in the collection of the Dublin Society, we had reason to believe that this is the case in the neighbourhood of Ballycastle, but we did not ourselves observe this formation in situ in that point. About half way between Ballycastle and Bushmills near Ballintoy, the chalk formation rises sufficiently high to disclose its substrata; a valley opening towards the sea, near White Park, shews that they here consist of the slate clay of the lias formation, with gryphites and ammonites. Farther east the chalk cliffs again emerge from the level of the sea immediately beyond Dunluce Castle, and continue to rise till they are broken off at the commencement of Portrush Strand. As they here exhibit nearly the same thickness which they possess near White Park, we are naturally led to expect the recurrence of similar substrata near this point; and accordingly, in the peninsula of Portrush, a singular rock is seen, divided by interposed masses of greenstone, but containing ammonites and gryphites, and possessing exactly that character which would be assumed by the slate clay before described, if indurated by the action of heat. In the explanatory notes accompanying the sections of the coast a more detailed account of this peninsula will be found.

The cabinet of the Dublin Society contains specimens of lias from the neighbourhood of Magilligan, about eight miles westward from Portrush, and close to the north-west angle of the basaltic area.

E. *Mulattoe or Green Sandstone.*

To the general account of this rock given in the Introduction, it may be added, that on treating different specimens with acids they were found to contain about nine-tenths of calcareous matter, the residuum consisting of green chloritic grains, mixed with quartzose sand or gravel.

The mulattoe is seen in Colin glen, a valley on the south-west of Divis hill near Belfast, and in several other places on the slope of that mountain; it is evidently interposed between the slate clay of the lias formation and the chalk. It occurs also at Cermoney, about five miles north-east from Divis. The chloritic grains in the mulattoe of Divis are small and very numerous, the calcareous base greyish and compact; it is traversed by slender veins of calcareous spar: besides the smaller grains of quartz, it contains a few larger pebbles with a reddish tinge.

Since it is not quarried for any economical purpose, we have no opportunity of ascertaining accurately the thickness or extent of the bed.

It is seen however near Larne, and considerably further north near Gerron point, occupying a position corresponding to that in which it occurs near Belfast, and it seems highly probable that it extends beneath the chalk throughout the intervals separating these points; indeed I am inclined to believe that where the series approaches to completeness, this member will seldom be found wanting.

In Murloch bay, where the line of chalk commences on the east of the greenstone mass of Fairhead, a thin seam of quartzose pebbles cemented by green sand, affords traces of this formation; it separates the chalk from a thick bed of red sand.

Along the western escarpment of the basaltic mountains in Londonderry, the mulattoe is seen underlying the chalk in Kedy Donald and Ballyness hills. Between Ballyness and Benbradagh, at the head of the vale of the Kelvin river, a wild circus opens, barred on the north by basaltic ridges, and having the insulated primitive district of Coolcroscrahan on the south: the Glen Ullin water and Donavenny brook rise also within the area, and flowing in a direction contrary to that of the Kelvin, join the Aghivey river itself, tributary to the Bann. Within this area a remarkable bed of marle occurs, which is mentioned here, on account of its containing numerous green particles; but it differs so essentially from the Mulattoe in its chemical composition, containing only one-fiftieth of calcareous matter, that it cannot with propriety, though resembling it in external appearance, be considered as the same rock: the base is a soft clay, greyish, with a slight red tinge; the structure is thin slaty; it contains some small worn quartz pebbles: the chalk has not yet been traced in this district, but along the banks of Donavenny brook, a breccia formed of chalk flints, imbedded in a calcareous cement, and underlying the basalt, seems to indicate its proximity. This breccia is probably connected with the aggregation of flints, usually interposed between the basalt and chalk, as described in the next article.

The subjoined list of the organic remains occurring in the Mulattoe of Ireland, will be found to agree closely with those presented by the green sand in England.

GENERA.	SPECIES.	PLACES.
Belemnite	.....	Colin Glen and Donald Hill
Venus ? Lin.	fragment of	Colin glen
Ostrea	Crista Galli	Ibid.
Ostrea	edulis	Ibid.
Arca.....	Glycimeris	Ibid.
Pecten.....	varia.....	Ibid.
Anomia	.....	Ibid.
Ditto	Gryphus, two varieties	Belfast Mountains
Mytilus	Crista Galli	Colin glen
Ditto	lithophagus ..... Lin. Tr. v. 8. p. 6. f. 1	Ibid.
Cardium?.....	.....	Ibid.
Serpula.....	.....	Ibid.
Dentalium	hexangulum	Ibid.
Pinna	lævis ?	Carrickfergus
Echinus	.....	Belfast Mountains

F. *Chalk.*

The chalk formation in Ireland has hitherto been frequently distinguished by the name of white limestone, its compact texture having caused those who were acquainted only with the superior beds of the English chalk formation to hesitate in admitting their identity: the occurrence of the cornu ammonis among the fossils of the Irish chalk was also supposed to furnish another distinctive character; in both these circumstances, however, it agrees with the lower beds of the English chalk; further, its geological position, (reposing as it does on the same bed of calcareous sandstone, with chloritic grains, which supports the English chalk) the analogy

of its fossils, and the absolute sameness of its general features, will no longer permit us to describe by a distinct name, this important formation.

It need not excite any surprize to find the floetz trap incumbent on a bed of such recent formation, since in the north of Italy it may be seen to rest upon strata still less ancient, and analogous to those which occur in the basins of London and of Paris.

The Irish chalk is seldom of a texture sufficiently loose to soil the hand, and in the few instances where this does take place, it is in a very slight degree: its general colour is either perfect white, or white with a very slight tinge of yellow; towards the lower beds it passes into an uniform ash colour, the texture then becomes still more compact. It is sometimes traversed by slender veins of calcareous spar, these are more frequent in the lower beds: it contains (though in very small quantity) kidney shaped nodules of iron pyrites; but the most striking of its imbedded contents are the flinty nodules which traverse the mass in regular horizontal strata, distant from each other, by an average interval, about two feet and a half; the flints cease in the lowest beds. Among the flints some of remarkable size, and of a regular and apparently organic figure occur; these are known by the name of Paramoudra, and are also found in the chalk of Norfolk. It is superfluous to describe farther the characters of these beds of flinty nodules than by saying, that they are precisely the same with those presented in every English chalk pit.

The average thickness of the chalk formation in Ireland may be estimated at between two and three hundred feet; the upper beds seem to have been partially redissolved before the basaltic mass was deposited upon them, since along the line of junction a confused aggregation of chalk flints exists, imbedded in the

lowest member of the trap deposit, which is usually a bed of ochreous bole: the flints so imbedded have usually themselves acquired a red tinge, apparently by percolation, from the oxidated iron of the stratum in which they lie.

This aggregation of flints, bedded in red ochreous bole, forms at Macgilligan, a stratum thirteen feet thick. It may be observed, also, near Larne and near Belfast, and seems indeed of almost universal occurrence.

List of organic remains found in the chalk of Ireland.

GENERA.	SPECIES.	PLACES.
Echinus	cidaris mamillata....	Kenbaan Antrim; Slievegallion Derry.
	scutatus	Pollen quarry near Agenloo Derry.
Terebratula..	vulgaris	Ballyness Derry.
	sulcata	Ibid.
Pecten	earless	Ballycreem Derry.

The foregoing specimens closely agree with the fossils of the English chalk.

Belemnites are common in most of the quarries opened on this bed in Ireland: many of the bodies in the English chalk, once supposed to be belemnites, are now regarded as the pallisadoe spines of the echinus. Some few, however, are undoubted belemnites; the Irish specimens appear to be generally true belemnites.

Specimens of cornua ammonis, from five inches to one in diameter, occur in the Pollen quarry; but not having myself examined these, I cannot say how far they agree with some of the very few varieties which are found in the lower strata of chalk in England. The flinty nodules often contain fossils similar to those of the surrounding chalk, and present, in addition to these, traces of alcyonia.

The chalk is frequently traversed by basaltic dykes, and often undergoes a remarkable alteration near the point of contact; where this is the case the change sometimes extends eight or ten feet from the wall of the dyke, being at that point greatest, and thence gradually decreasing till it becomes evanescent. The extreme effect presents a dark-brown crystalline limestone, the crystals running in flakes as large as those of coarse primitive limestone; the next state is saccharine, then fine grained and arenaceous; a compact variety having a porcellaneous aspect and a bluish-grey colour succeeds: this towards the outer edge becomes yellowish white, and insensibly graduates into the unaltered chalk. The flints in the altered chalk usually assume a grey yellowish colour; the altered chalk is highly phosphorescent when subjected to heat.

Examples of this conversion of the chalk into granular marble may be seen on the east slope of Divis mountain, near Belfast, in a ravine to which Dr. Macdonald has given the name of Allan's Ravine, in honour of a mineralogical friend.

They are again exhibited in the neighbourhood of Glenarm, where a singular compound dyke, consisting of three branches, traverses the chalk: the included masses of which are altered in the manner above described.

A dyke, very similar to the preceding, occurs in the isle of Rathlin, near Church bay, and produces the same effect on the chalk. This dyke appears to be resumed on the opposite point of the Antrim coast at Kenbaan head, where the granular marble is likewise found. (See section, plate 10. and the explanatory notes.) A dyke near Ballintoy affects the chalk in the same manner.

In the south-west extremity of Antrim the same marble is said to occur near a whin dyke; the spot assigned is Bamersglen, near Trummery, about one mile north-east from Moira.

Many more examples of this very interesting fact would, there is little doubt, be found on further examination; but those cited are sufficient to prove that it is not unfrequent.

On the shore, a little to the west of the pier of Ballycastle, a singular vein occurs in the chalk, which there forms the inferior portion of a cliff capped with basalt; the basalt immediately incumbent on the chalk approaches to the character of wacke. The vein in question is calcareous, but contains imbedded balls of wacke; to the presence of which the difference of its characters from those of the chalk that it traverses, may perhaps be attributed. The limestone forming the vein is compact, breaking spontaneously into parallelopipeds, the greater side of which is perpendicular to the direction of the vein; it contains about nine-tenths of calcareous matter, the residuum appearing to be clay, with some specks of bright mica. The width of the vein is 17 feet; its direction N.E. S.W. 33°.

Near the top of the stratum of chalk which crowns the cliffs of Murloch bay, a bed five or six feet thick, of wacke approaching to basalt, occurs interstratified with the chalk in a conformable position.

I shall now proceed to trace the outgoing of the chalk round the basaltic area, beginning in the south-eastern quarter, and pursuing it to the south-western, inserting in parallel columns the names of places observed in the order of their succession along this route, and the observations I had an opportunity of making concerning the dip of the strata, the elevation of the formation, &c.

PLACES.	DIRECTION OF THE DIP.	ANGLE OF DIP.	HEIGHT OF THE LOWER LIMIT OF THE FORMATION.	HEIGHT OF THE UPPER LIMIT OF THE FORMATION.	GENERAL REMARKS.
Magheralin, near Moira, county of Down....	North west 8°.	from 30 to 32.	.....	.....	The chalk proceeds from hence towards the White mountains near Lisburn, by Soldierstown and Brookhill; it forms a low table land. At Magheralin the bluish-grey variety occurs.
White mountain, near Lisburn Antrim	North-west 28.	from 38 to 40.			
Colin Glen, south-west of Divis mountain, near Belfast	.....	.....	.....	about 450 feet above the level of sea.	The line of junction, with the basalt, is not strictly horizontal but very irregular.
East slope of Divis	.....	.....	.....	about 450 feet.	
Cave hill	.....	.....	.....	768 feet.	
Carmoney mountains & Carrickfergus hills	.....	.....	.....	considerably lower than in Cave hill.	
Port Muck, north-east of the isle of Magee ..	.....	.....	emerging from the sea.	.....	The east coast of Magee is faced with a bold range of precipices, called the Gollins, which are entirely basaltic, the chalk being sunk below the level of the sea.
Shore of Lough Larne, about 1 mile south from the town	.....	.....	but little elevated above the sea.	about 300	From hence the line of the chalk is distinctly traced in the sections of the coast.
Gerron point	.....	.....	.....	.....	
Lurgethan mountain, near Newton Glens	.....	.....	.....	.....	Hence the mountain mass of red sand chalk and basalt, sweeps inland in a curved line towards Teabulliagh and the head of Glendun.
Mountain of Teabuliagh, 3 miles north-west of Newton Glens, forming a ridge between the rivers Glenaan and Ballyeemin	.....	.....	.....	....735.....	
Eastern slope of Slieve Norry, towards the head of Glendun	.....	.....	.....	....885.....	
Holster hill, middle Cushleak	.....	.....	.... 695....	.....	Here the mica slate of Cushleak, receives a cap of red sandstone, chalk, and basalt

PLACES.	DIRECTION OF THE DIP.	ANGLE OF DIP.	HEIGHT OF THE LOWER LIMIT OF THE FORMATION.	HEIGHT OF THE UPPER LIMIT OF THE FORMATION.	GENERAL RTMARKS.
Murloch bay, on the east of Fairhead	.....	.....	560.	652 the summit of the cliff.	
Benvaan, on the south of Murloch	.....	.....	.....	885	This forms a platform of chalk, covered with grass.
Ballypatrick, 3 miles south from Fairhead....	.....	.....	.....	.... 622	
Knocklead, an insulated mountain, 2 miles south from Ballycastle ..	....S.W.....	very small.	.....	.... 895	The intersection of the conical surface of Knocklead with the plane of the chalk stratum, forms a zone completely encircling its middle region. In the exact direction of that plane the stratum of chalk (here interrupted by a deep valley) is resumed on the slope of the opposite mountain to the south. Towards the west it catches the plain near Ardmoy, where pits are opened. At Corky, 6 miles south from Ardmoy, and higher up the same valley, there are also chalk pits.—See Dr. Richardson's papers.
Ballycastle, west of the river	..S. W. 17...	from 15 to 18.	.....	emerging from the sea.	The upper limit of the chalk stratum through the line of coast between these points, about 30 miles distant, keeps nearly the level of the sea, vaccillating slightly on either side of that level, but seldom rising very high, and probably seldom submerged very deeply beneath it: the same description applies to the opposite island of Rathlin. It is unnecessary here to insert detailed particulars, which will be found represented in the sections of the coast.
Down hill, on the west of the river Bann, in the county of Derry	....N.E.....	.....	.....	emerging from the sea.	
Benyavenagh	.....	.....	on the north side but little elevated above the sea, on the south about 200 feet.		
Kedy	....N.E.....	.... 10.	....550?....	.... 600	The deposit here hardly exceeds forty feet.
Donald hill	.....	.....	.... 800	.... 900	The deposit here increases in thickness to 100 feet: the upper beds are soft enough to soil the fingers, the lower quite compact.
Ballyness	.....	.....			
Benbradagh	.....	.....			The thickness of the deposit here is greatly increased, amounting to no less than 363 feet: it is less regularly stratified than usual. Towards its upper extremity it wears the character of considerable detached masses; in Kedy Donald and Ballyness mulattoe is interspersed between the chalk and sandstone, but in Benbradah they appear to be in contact.

In Carintogher and Cragnashoack the chalk appears to be wanting, and the basalt to repose immediately on the sandstone; but in the insulated mass of secondary strata which cap the primitive mass of Slieve Gallion (on the south of the great valley of denudation, through which the Mayola flows) the chalk again appears underneath the basalt, and there attains its greatest elevation, being quarried at the considerable height of 1460 feet above the level of the sea, the deposit is however thin and the strata much split.

On the east of Slieve Gallion is a valley about three miles in breadth, occupied chiefly by red sand and marle, and succeeded near Moneymore by a ridge of elevated ground, exhibiting chalk, rising over the sandstone and surmounted by basalt; this ridge rises from Lough Neagh. At Ruskey it is but little raised above the level of that lake; it ranges in a direction towards the north, passing a little to the west of Magherafelt, a continuation of it may be traced to the east of the insulated primitive district of Coolcoscrahan, thence bending round the source of the Kelvin, and joining the lofty chain before described near Ballyness. The western escarpment of this ridge may be considered as limiting in that direction the great basaltic area. Benbradagh, Cragnashoack and Slieve Gallion, which lie without the boundary so assumed, forming insulated and outlying masses, separated from the principal and continuous basaltic region by vallies of denudation.

The elevation of this ridge does not appear to be very considerable; it seems probable that the mulattoe will be found underlying the chalk in this ridge as it does in the hills with which it is connected from Ballyness to Benyavenagh.

The south western limit of the area of chalk would be determined by a line from Moneymore to Magheralin, this passes diagonally across Lough Neagh, the strata which occur along it are of course concealed

but it is said that chalk makes its appearance at Temple Patrick, near the north-east angle of the lake, being there exposed by the excavation of the deep valley through which the Six mile water flows.

Flœtz Trap.

This formation in Ulster comprises the following members.*

1. Tabular basalt,
2. Columnar basalt,
3. Greenstone,
4. Greystone,
5. Clinkstone porphyry,
6. Bole or red ochre,
7. Wacke,
8. Amygdaloidal wacke,
9. Wood coal.

* The section given by Dr. Richardson of the cliffs near the Causeway well illustrates the arrangement of these substances in constituting the aggregate mass of flœtz trap.

		Feet
1.	Basalt rudely columnar	60
2.	Red ochre or bole	9
3.	Basalt irregularly prismatic	60
4.	Columnar basalt	7
5.	Intermediate between bole and basalt	8
6.	Coarsely columnar basalt	10
7.	Columnar basalt, the upper range of pillars at Bengore head	54
8.	Irregularly prismatic basalt. In this bed the wacke and wood coal of Port Noffer are situated	54
9.	Columnar basalt, the stratum which forms the Causeway by its intersection with the plane of the sea	44
10.	Bole or red ochre	22
11. 12. 13.	Tabular basalt divided by thin beams of bole	80
14. 15. 16.	Tabular basalt occasionally containing zeolite	80

The following simple minerals occur imbedded in the rocks of this series; they are enumerated in the order of their more frequent occurrence.

1. Granular olivine.
2. Augite.
3. Calcareous spar.
4. Steatite.
5. Zeolite, comprizing analcime, mesotype, stilbite & chabasite.
6. Iron pyrites.
7. Glassy felspar.
8. Chalcedony; passing sometimes into semi-opal.

Granular olivine in disseminated grains seldom fails in the tabular basalt; and sometimes occurs also in greystone. It has a remarkable mode of decay, becoming tender, and iridescent.

Augite usually accompanies greenstone and sometimes greystone. Steatite is almost exclusively limited to the prismatic basalt; and it is likewise the only heterogeneous ingredient I have observed in it. It exists in small round specks, of a bottle-green colour so dark, that it is not easily discernible from the mass itself: it has a dull and waxy appearance; is soft, the streak greyish.

Glassy felspar characterizes the clinkstone porphyry. Calcareous spar, zeolite, iron pyrites, and chalcedony usually occur in association with the preceding substances.

Since the flœtz trap forms the superficial rock of the area we are now to describe, it may be proper to insert in this place a list of the most remarkable hills by which that surface is diversified, and some other remarks on its general forms. In the list of hills, the same order will be followed as before in tracing the chalk, beginning with the south-east angle and ending with the south-west. The thickness of the trap formation where it has been observed will be added.

Eastern chain from South to North.

	Height of the hill above the level of the sea.	Thickness of the cap of trap.
Divis	1475	944
Cave-hill	1064	296
Agnew's-hill	1450	
Slievemish	1398	
Teabuliagh	1235	500?
Coolnagopag	1130	
Ballypatrick	955	333
Knocklead	1820	930
Fairhead	535	
Cross hill	508	144

On the Northern Coast.

Croaghmore		
Bengore	328	
Pleskin	354	
Cliffs above Dunluce	157	
Slieve Ard, the highest point of the Island of Rathlin	372	

Western chain from North to South.

Benyavenagh	1145	900?
Kedy	1030	426
Donald's-hill	1399	399
Benbradagh	1569	363
Cairntogher	1600	
Cragnashoack	1864	275
Slievegallion	1624	165

The ridge above Moneymore has not been determined.

The above table will convey an accurate idea of the general configuration of the circumference of the basaltic area.

The aggregate mass of all the formations constituting the third system of mountains, appears to form a species of basin of which the lowest point is situated near the center of the valley of the Ban; hence they rise, towards the south-east, where they lean against the exterior chains of the Down mountains; towards the north-east, where the primitive rocks of Cushleak emerge; and towards the south-west, where they abut on the great central chain of Londonderry. In this last direction, all the strata attain their greatest height, the chalk standing in Slieve Gallion at 1460 feet and upwards, and the basalt in Cragnashoack at 1864 feet. It is rather remarkable that the cap of basalt grows gradually thinner in proceeding towards the same point. On the north-east edge of this basin, the inferior limit of the basalt, or its junction with the chalk, is 500 feet lower, but the thickness of the cap of trap, increasing in the inverse ratio of this diminution of level, raises the summit of Knocklead till it nearly rivals Cragnashoack. In the south-east border, at Cave hill, the line of junction is about 200 feet lower than in Knocklead; the cap of trap is there very thin, but in the adjacent summit of Divis nearly equals in thickness that which covers Knocklead. At Divis the line of junction is depressed 200 feet below the level which it occupies at Cave hill.

The high chains which form the borders of this basin on the east and west, present a far less rapid slope towards its interior than towards its circumference.

Thus between the towns of Belfast and Antrim, the watershed or highest point of the road which there crosses the eastern chain, is situated three miles and a half from Belfast, and eight miles and a half from Antrim, at the elevation of 997½ feet above the level of

the sea; the ascent therefore on the side of Belfast, which is that of the outgoings of the strata, is 285 feet per mile, and 117½ only on the Antrim side, which is that of the dip of the strata collectively taken.

The Western chain, between Newton Limavaddy and Colerain, was found by the same method to have a fall of 177 feet per mile on the side of its outgoing, and of 110 feet in that of its dip.

The detached summits of the principal basaltic mountains form ridges which exhibit a general tendency to arrange themselves in a direction pointing north and south.

1. *Tabular Basalt.*

This is the prevailing rock of the trap district under consideration, occupying at least nine-tenths of its whole area.

It is disposed in strata, or rather beds, of considerable thickness.

The characters of this rock are too well known to need description.

Some of the strata contain imbedded specimens of most of the simple minerals already enumerated as subordinate to the flœtz trap formation; others are vesicular; others of an homogeneous texture. The strata also vary materially in their degree of induration, and they are occasionally separated by beds of bole, amygdaloidal wacke, &c.

2. *Columnar Basalt.*

The strata of columnar basalt seem to occur almost exclusively towards the northern boundary of the basaltic area.

The pillars are composed of the most compact and homogeneous variety of basalt, containing a small quantity of steatite occasionally imbedded in its mass, and possessing the property of being more or less sonorous when struck by the hammer.

Besides the well known columnar strata exhibited by the Giant's Causeway and adjoining cliffs, of which the principal is 54 feet in thickness, and a second 44 feet, similar strata are exhibited in the following places.

In Glen Ravel, at the distance of about four miles from Cushendall, I observed in the bed of a stream flowing from the mountain of Slieveance, an abrupt façade of tabular basalt, approaching the columnar form, fronting the north-east quarter.

In the isle of Rathlin, there are several systems of pillars along the northern coast: at Kenrammer, "the thick Head," I counted no less than seven in succession all nearly vertical, but none very regular; some were matted amongst themselves.

At Thivigh, "the side-point," there is a sort of headland sloping down into the sea; it is covered with grass, but the section sideways exhibits two assemblages of square pillars, not unlike those of Fair-head; the lower system comprehends those of the greatest dimensions; the upper one, those that are the best defined.

Rhue-na-Scarse or Roanscarave, in the town-land of Craigmacagan, presents another projecting point of land, with a real causeway, in neatness hardly inferior to the Giant's causeway itself, the pillars being almost vertical; the pavement is nearly flat or horizontal.

At Doon-point, tabular basalt alone occurs; whence it appears that the late Dr. Hamilton has mistaken it either for Thivigh or Rhua-na-Scarse.

Near Ushet-haven, on the south-east side of a hill, named in Irish Broagh-mor-na-Hoosid, there is another very elegant causeway:

it runs to the extent of four hundred and sixty yards in a direction from north-east to south-west, coming up to the top of the hill towards the latter point, and falling down the opposite way. The pillars are five and six sided; a few have seven sides. I measured two of the largest size; one of them was three feet, the other two feet eight inches in diameter.

Along the slope of the hill, the pillars are so completely disengaged from the soil, that I could easily determine their angle with the horizon; I found it 22°.

On the main at Knocksoghey, the highest ridge of land between Ballycastle-bay and White-Park-bay, some floetz-trap pillars, most of which are neatly defined, are quarried for building. Another quarry of the same rock has been opened at Ballynastrade near Ballintoy.

Croaghmore, one of the hummocks that lies at the greatest distance from the coast, is completely formed of an assemblage of pillars almost vertical, and jointed as is usually the case.

In the town-land of Craigahulliar, one of the most beautiful colonnades that can be seen lies under a mass of tabular basalt. Its extent is only one hundred and ninety feet, in a direction from east-north-east to west-south-west, presenting its façade towards the north-north-west: the pillars are from eighteen to fifteen feet in height, and the individual joints of which they are composed, one foot and a half; most of them are five-sided, others have four and six sides; they are remarkably sonorous.

I have remarked some rude attempts of the floetz trap to assume a prismatic configuration at the bridge of Bushmills, at Magilligan, and on the north-west side of Donald-hill, but not distinct enough to be more particularly noticed.

It was natural to suppose that basaltic pillars, containing so

much iron and standing in a situation approaching to perpendicular in many instances, might in time become natural magnets, with the south pole uppermost and the north pole lowermost.

This however, I have never found to be the case; but I remarked a complete polarity in a rounded block of greenstone that was lying rather deep in the ground on the top of Donald-hill in the county of Londonderry: the needle of a pocket compass that had been laid upon it went half way round and stood there permanently, the north pole of the needle pointing to the south and the south pole to the north.

The pillars of Fairhead, and the adjacent summit of Fairhead, are composed of greenstone containing augite.

Basalt passes into greenstone in the most imperceptible manner: in the first stage, the felspar exists under the form of short, scaly parts either white or greenish; the texture becomes more finely granular and crystalline; the fracture in the great is not into flat conchoidal pieces, but more usually into irregular and blunted fragments. This finely granular and almost compact greenstone is also more tough than common flœtz-trap.

3. *Greenstone.*

It is difficult to determine the precise geognostic relations of the basalt and greenstone in this district; but since the latter here occupies an extent comparatively small, it must be considered as a formation subordinate to the former; whether however they form distinct beds, or pass insensibly into each other by a gradual transition, is as yet undecided.

The greenstone columns of Fairhead and Cross hill are destitute

of the regular articulations and neatness of form which distinguish the basaltic pillars of the Causeway; they form enormous prismatic masses, often quadrilateral, and these latter appear to be formed of a congeries of smaller prisms, aggregated in a manner which brings to the mind the clustered assemblage of shafts forming a Gothic column: the greatest length of these columns is not less than 250 feet; the greenstone is highly crystallized, the concretions being distinct and large, and contains augite.

Slievemish, a remarkable mountain, which lies like a colassal landmark in the middle of the county, is from its basis to its summit composed entirely of greenstone, thus forming a mass of nine hundred feet in thickness.

Notwithstanding Slievemish has at a distance the appearance of a cone, yet it is, like all the other mountains in Antrim, much more extended in the direction from north to south than in a transverse section: the ascent is steep and almost impracticable on the west side, where we rise to the top by a succession of short terraces similar to a flight of stairs.

The greenstone is here remarkably beautiful, being of a tender mountain green, interspersed with crystals of augite and granular olivine; the fracture is in flat or scaly concretions: it lies in distinct tabular masses two or three inches thick, perpendicular to the horizon, or sometimes with a slight dip to the westward.

The mountain of Teabuliagh near Newton Glens, has a cap of finely granular greenstone five hundred feet in thickness.

The rock which overlies the chalk at Magheralin, may perhaps with greater propriety be arranged as greenstone than basalt.

4. *Greystone.*

The top of Squires hill and of Cave hill, near Belfast, are both composed of this rock.

5. *Clinkstone Porphyry.*

The little table-land forming the summit of Divis mountain consists of a beautiful clinkstone porphyry of a reddish brown colour, containing elongated lamellar crystals of glassy felspar, and concretions of bluish white chalcedony: the rock is very sonorous. A variety of clinkstone porphyry also occurs in the neighbourhood of the old red sandstone, near Newton Glens, so situated that it is difficult to pronounce what is its position or geognostic relations with regard to that rock: it will be more particularly described in the explanatory notes on the section.

The porphyries of Sandy-brae, &c. in the interior of the basaltic aræ, of which the geognostic situation is likewise uncertain, are referred to a separate article at the end of these extracts.

6. *Bole or Ochre*

Occurs in beds of various thickness, alternating with and underlying the basaltic strata in the cliffs near the Giant's Causeway; in Cave hill, on Macgilligan, along the east side of Ushet lough in the isle of Rathlin, and in several other places. Although the specific gravity of the bole is low it contains a great proportion of iron, (acting powerfully on the magnet) and might with propriety be classed among the earthy and ochrey ironstones.

Near the Giant's Causeway it is confined to the lower portion of the cliffs, where beds of it in various states are seen, sometimes assuming the character of a decided red ochre, sometimes variegated red and cream yellow, containing imbedded heterogenous portions, wearing at a small distance the external appearance of agates, but when examined found to be as tender as the softest steatite. Specific gravity 1,92.

Similar characters apply to the bole in other places. The lowest bed of the trap formation where it comes in contact with the upper surface of the chalk, and contains chalk flints imbedded in its mass, is most generally a red ochrey bole.

7. *Wacke.*

This rock appears to be of extremely rare occurrence in the Ulster trap series; it is found however in Portnoffer near the Causeway, underlying the upper stratum of columnar basalt, and alternating with the wood coal described in article 9; the thickness of the whole amounting to eight feet: it forms vesicular concretions of a trapezoidal or rounded figure; without coherence; texture dull and earthy, with a few specks of mica; the colour varies from yellowish grey to brownish grey, apparently derived from iron ochre. The bed or horizontal dyke of wacke traversing the chalk cliff at Murlough bay has before been noticed. A seam of wacke, not more than three or four inches thick, is interposed between the greenstone and sandstone of Cross hill.

8. *Amygdaloidal Wacke.*

Colour variegated reddish or greyish brown; fracture dull and scaly; soft, owing to seatite which occurs both in grains and in larger disseminated concretions.

It also contains radiated zeolite in considerable abundance, in concretions of all sizes: and cubic zeolite has been found at Benyavenagh, but is very rare.

Chalcedony is likewise found imbedded in this rock, but is not very common.

9. *Wood Coal*

Has been found in seams varying from two inches to four or five feet in thickness, alternating with trap rocks near Ballintoy; associated with the bed of wacke, underlying the upper columnar stratum in the cliffs of Portnoffer on the east of the Giant's Causeway, at Killymorris near the center of the basaltic area, and at Portmore and other places along the eastern shore of Lough Neagh. At Portmore the beds are said to exceed considerably in thickness the dimensions above given. The texture of the wood is often remarkably distinct, and indicates that it is a species of fir. It has even been asserted that the roots and branches of the trees could be traced.

The wood coal at Portnoffer has the exterior surface of some of its fragments penetrated to a certain depth by small nests of augite imperfectly crystallized.

ADDENDA.

1. Account of certain porphyritic rocks of doubtful formation.
2. Alluvial formations.

Porphyry of Sandy-brae.

Near the centre of the basaltic area, and about seven miles north north-east from Antrim, a very remarkable district occurs, in which a reddish variety of clay porphyry prevails.

This district is situated between Templepatrick on the south and Kells and Connor on the north, including an area of about four English miles; proceeding from Connor in a westerly direction, you first meet the porphyry formation at Carnecome, scarcely a mile distant from that village, and continue upon it for about three miles, as far as the source of a small brook called Loonburn, which empties itself into the Six mile water above Templepatrick.

Numerous small hills are scattered over this tract; Sandy-brae, Brown Dodd, Tardree, Forthill, and Carnearny, are the names of the most considerable. These are all low hummocks, exhibiting in their outline a striking approach to regular segments of circles, and, as Dr. Richardson has well remarked, strongly contrasted with the basaltic ridges which every where surround the porphyritic area, and uniformly present an abrupt escarpment on the one side, and a gentle slope on the other. The hill of Sandy-brae rises 537 feet above Doagh, which, from its situation relatively to Lough Neagh, cannot be estimated at less than 200 feet above the level of the sea.

The clay porphyry of this district has a reddish brown basis, containing imbedded in it concretions of smoky quartz, earthy and glassy crystals of felspar, and olivine. Specific gravity 2,43.

It is usually much weathered, its decomposition giving rise to a red sandy soil, whence the district derives its name.

At Carnecome is a large standing block of clay porphyry, of an ash-grey colour, containing the same ingredients as that above described.

Pitchstone porphyry and pearlstone porphyry occur apparently as subordinate members in this formation.

Two large masses of each variety may be seen at the bridge across the Loonburn, on the road from Connor to Doagh.

Pitchstone Porphyry of Sandy-brae.

The most sound and interior part is bluish black, possessing a splendent and vitreous lustre: its specific gravity is 2,52; a little nearer to the surface it passes to olive green, with a waxy texture, and has a specific gravity of 2,50; at the surface it appears yellowish green and rather earthy, with a specific gravity of 2,40; all these different shades sometimes occur in the same specimen, and appear evidently to result from decay.

Engaged in the basis round concretions of smoky and vitreous quartz, with lamellar crystals of glassy felspar possessing a yellowish tinge occur. Common opal, nearly approaching to precious opal, accompanies this pitchstone porphyry; it is either disseminated in plates or in small strings.

Pearlstone Porphyry of Sandy-brae.

The texture is formed of vesicular and distinct concretions loosely coherent, of an elongated or irregular shape, the angles being smooth

and rounded. Their colour is smoke-grey or bluish, with a pearly lustre. They seem formed of concentric and very thin coats. The fracture of this mineral is imperfectly conchoidal; it cuts glass but faintly, and emits a faint argillaceous smell when breathed upon. Fragments, exposed to the blowpipe, intumesce to four or five times their first volume, fusing into a foamy and light glass, not unlike pumice stone. Radiated zeolite is the only fossil I am acquainted with that resembles pearlstone in the characters of fusion. The specific gravity of two different specimens, I found 2,38.

About 76 miles to the north of this district, at Ballycloghan, two miles north-west from the village of Broughshane, there is a bed of clay porphyry extending towards Slieve Mish on the south-east; it is quarried as a freestone, and when raised in thick slabs, is used for window seats.

The basis is compact and sometimes earthy, of a greyish white colour; it contains imbedded concretions of smoky quartz, lamellar crystals of white felspar, and a few interspersed plates of brown mica; it adheres to the tongue slightly, and fuses into a transparent but frothy enamel; the specific gravity is 2,43.

The occurrence of a porphyritic district, surrounded on all sides by a vast area of basalt, must be considered as one of the most singular facts which the country we have examined presents. The question to what formation do these porphyritic rocks belong, immediately suggests itself, but the materials which observation has hithereo afforded cannot be considered as authorizing any decided answer. Many geologists, among whom it will be sufficient to mention Dr. Macdonnel and Dr. Richardson, consider them as referable to the class of transition or primitive rocks, and regard their appearance in this situation as the result of a vast denudation which

has stripped away the basaltic masses which once covered them. This opinion seems principally grounded on the resemblance between these porphyries and those occurring in more ancient countries.

Another opinion represents these rocks as subordinate members in the flœtz trap formation. In favor of this it is urged that the general dip of the strata constituting the great basin of the basaltic area must (unless we suppose them to have been affected by a great dislocation and elevation) have carried the substrata on which the trap reposes to a much lower level than that which is actually occupied by the hillocks in question; and it has been asserted as a corroborating fact that the porphyry is actually seen to rest upon the basalt in one of the ravines which traverses the district, while still lower at Templepatrick, the stratum of chalk on which the basalt really reposes makes its appearance.

The occurrence of similar rocks subordinate to flœtz trap is by no means unexampled in other countries. Near Newry a narrow dyke of pitchstone porphyry extends for half a mile to the west, and in a continuation of the same line clay porphyry occurs. This dyke traverses sienitic rocks: an account of it is given in Dr. Fitton's notes on the mineralogy of the vicinity of Dublin, p. 53.

A singular formation of clay porphyry approaching to clinkstone porphyry occurs near Newtonglens in Antrim, seemingly associated with the old red sandstone; it is particularly described in the notes on the sections of the coast, appended to the present paper.

2. *Alluvial Formations.**

At B. Macrevan, in the county of Antrim, half way between Glenevey and Lough Neagh, bituminous wood in disseminated pieces loosely imbedded in a loamy soil has been found.

Two shafts, each sixty feet deep, were formerly sunk to obtain it, but are now abandoned, the stock being exhausted. I however procured some specimens. The wood has evidently retained its fibrous texture, and burns with a vivid flame; specific gravity 1,124.

Not far from B. Macrevan, at B. Vorally, in Sandy Bay, there are still remaining on the shore, a few stumps of bituminized wood, the fissures of which are penetrated by silex, and sometimes even lined by quartz crystals. It does not flame, and its specific gravity, from the quartz it contains, amounts to 2,267.

It was once the general opinion that the waters of the lough had the property of petrifying, and that the quartz contained in the bituminous wood of Sandy Bay had been deposited from them. The experiments however, made by Mr. Tennant during his stay at Belfast, appear to discountenance that belief, since he found no traces of silica whatsoever in the water of the lough.†

* On the shore of Belfast Lough, traces of an ancient forest have been discovered beneath a peat bog. Here a singular phenomenon (first communicated to the Geological Society by Dr. Mac Donnel) occurs, hazel nuts being found, the kernels of which are often converted into calcareous spar, while the shells remain unaltered. I am not aware that the remains of the elk, so common in the alluvial districts of other parts of Ireland, have yet been found in this quarter.

† As this is the only part of Dr. Berger's notes, in which Lough Neagh is mentioned, I have taken the opportunity of stating some facts concerning it.

Its height above the level of the sea is 132 feet.

Its greatest depth between Arboe and Gartrea points nearly in the centre, 45 feet

Its greatest length from north-west to south-east, 19 miles 6 furlongs.

Its superficial contents 97,775 acres.

A constant tradition has prevailed in Ireland, at least since the days of Giraldus Cambrensis, that it owes its origin to some violent convulsion.

The northern and eastern shores of the lough presents several sandy beaches, in which fine chalcedonic pebbles are found.

The penetration of the wood by the siliceous matter is sometimes compleat; sometimes one extremity of the same fragment is thus petrified while the other remains in a ligneous state. The oak, the holly, and the hazel appear to have been the trees thus affected.

A phenomenon occurring in some caverns near the Black Rock, on the south of Church Bay in the isle of Rathlin, may be properly referred to this article.

These caverns (four in number) although excavated in the basaltic rock and at a point remote from any calcareous formation, are yet invested with calcareous stalactites, depending from their roofs, and by their droppings upon the floor depositing a crust of about an inch in thickness.

This circumstance appears worthy of attention, since the calcareous matter seems evidently, from the situation of the caverns, to have been derived from that which enters as a chemical ingredient into the composition of the basaltic rock, separated from the mass and deposited in its present situation by the percolation of water which the rain or springs must have furnished.

It proves therefore the permeability of basalt which has sometimes been denied, and gives countenance to the opinions of those who consider the nodules of calcareous spar and zeolite, occurring in the amygdaloidal varieties, as the results of an infiltration which has gradually filled up what were once vesicular cavities; it is remarkable that the substances so occurring are such as the chemical constitution of the matrix would qualify it to afford by a similar process; and in the instances above described, that very process may be detected passing under our immediate observation.

A vesicular variety of basalt, of which the pores contain water, occurs at Ballylaglan on the north of Coleraine. Dr. Richardson has mentioned it as a proof of the aqueous origin of basalt, believing

it impossible for the water contained to have insinuated itself since the original consolidation of the rock; but it has been found that by heating this basalt, the water may readily be driven off, and doubtless the same pores which allow its escape would with equal facility permit its entrance.

Descriptive Notes referring to the Outline of Sections
Presented by a part of the coasts of Antrim and Derry,
Collected by the Rev. W. CONYBEARE, M.G.S.
From the joint Observations of
The Rev. W. BUCKLAND, M.G.S. Reader in Mineralogy to the University of Oxford,
And himself, during a tour in the Summer of 1813.

The Section, Plates 10. 10*. accompanying these notes, exhibits a line of coast extending rather more than fifty miles from the promontory on the south of Glenarm* in Antrim, to the strand of Macgilligan in Londonderry, where the basaltic mountains receding to the south finally quit the vicinity of the sea.

* The first point in which the cliffs of the Antrim coast expose sections of the basaltic rocks, is Blackhead, on the south-east of the peninsula of Magee; this point is (following the indented line of the coast) more than twenty miles to the south of that at which the delineations accompanying this paper commence: our information concerning that interval not being sufficiently precise to admit its being exhibited in such a form.

The following short notice will however contribute in some measure to supply the deficiency, and being prefixed to the descriptions in the text will render them a continnous survey of all that part of the basaltic area which presents a precipitous face towards the sea.

From Blackhead the eastern coast of the peninsula of Magee exhibits a long and lofty range of basaltic cliffs called the Gobbins, extending nearly eight miles towards Portmuck at the north-east extremity of the peninsula; near this point the chalk emerges from beneath the basalt, and the lias from beneath the chalk. Hence to the mouth of Larne lough the cliffs cease, the hills rising with a gradual acclivity from the beach; the same

Throughout this space the cliffs present a series of highly interesting and instructive sections, which indeed leave us little to desire in elucidating the structure of this important district, since they traverse and expose in succession all its constituent formations from the mica slate to the floetz trap.

In endeavouring to lay before the Society a transcript from these records of nature, the general principle adopted has been that of a combined series of elevations, projected upon vertical planes of which the direction is continually shifting so as to be always parallel to the greater flexures of the coast: but, since it appeared in many instances that the introduction of perspective would convey a clearer idea of the phenomena to be represented, the principle above laid down has often been departed from; and the delineations in their present state cannot be considered either as elevations or perspective views, in any strict sense. Two principles which cannot in truth be combined have certainly thus been forced together, but it is hoped usefully so with reference to the information to be conveyed.

To those who consider the varying aspects assumed by the same points when viewed under different angles in sailing past them, it must be obvious that much of incorrectness will of necessity intrude into the attempt of persons not practically ex-

character is applicable to the opposite side of the lough near Larne: the chalk and lias continue to occupy the level of the sea through this space, but about two miles to the north of Larne the chalk again sinks beneath the low basaltic cliff of Black-cave-head; a ridge of the same rock extends from hence skirting the beach for three miles to Ballygelly head, a promontory exhibiting rude and irregular columns; near this point the inferior strata emerge, but from the flatness of the coast being low do not render themselves distinctly visible. About three miles beyond Ballygelly-head however the red marle (No. 4 of the Introduction) may be traced, and about two miles further the lias begins to show itself in the southern extremity of the Deer park hill of Glenarm: this is the point at which the engraved section commences.

perienced in surveying, to construct such projections as have been described from their detached sketches; and to such objections it is felt that the present example lies particularly open: it is indeed offered merely as an approximation to a correct representation. Such as it is, however, it is presented to the Society, in the belief that the errors are not of a nature to interfere with fidelity in laying down the great geological features which distinguish this interesting coast, and that these features are in themselves so important as to render any delineation which might in this respect (however imperfect in others) pretend to some degree of accuracy, desirable.

In describing these sections the very ample information collected by Dr. Berger concerning this district, will render it unnecessary to exceed the limits of a rapid survey; this I shall commence at the south-east extremity of the line represented, proceeding towards the north-west.

In this direction the lias formation is seen at the extremity of the section occupying the lower regions of the promontory over which the Deer park of Glenarm extends, near its southern point; the ground here ascends with a rapid slope, above which cliffs of chalk covered by basalt rise to a considerable height: advancing towards the north the lias dips beneath the level of the sea, and the beach is skirted by a chalk cliff.

On doubling the promontory, Glenarm presents itself situated in a narrow valley bounded on the east by the Deer park hill, and on the west by Bellaire hill, both of which in their sections towards the sea exhibit cliffs of chalk covered by basaltic platforms. The distant hill seen rising above the opening of this valley, is Slieve Mish, it consists entirely of greenstone. Near Glenarm is the remarkable compound dyke mentioned in page 172.

The headlands of Glenarm on the south, and the bold promontory of Gerron on the north, include a bay which extends for six miles between them. Towards the centre of this bay the coast is generally flat, but a low bank of trifling extent called the braes of Carnalloch, here displays the red marle and sandstone (No. 4. of the Introduction); and the lias and green sand (No. 3 and 2.) may be traced between the chalk of Bellaire hill and this point; these formations occupy the base of the mountains which are seen skirting this bay at a small distance inland, and of which the superior regions are exclusively composed of rocks of the floetz trap formation. The summits of these mountains considerably exceed 1000 feet in height. The cliffs of Gerron point are formed by the abrupt termination against the coast of a ridge connected with them.

These cliffs exhibit basalt towards the summit, and chalk in their central regions; the beds on which the chalk reposes are concealed along the base of the promontory by enormous masses of the superior strata, which have subsided in this direction and form a range of advanced terraces, causing the headland when viewed at a small distance, to appear as if composed of four strata alternately chalk and basalt. Those who have visited the southern coast of the Isle of Wight will on seeing Gerron point be strongly reminded of the similar subsidence there distinguished by the name of the under-cliff.

After doubling Gerron point a scene of the greatest magnificence gradually discloses itself; the ridge running westward from Gerron is seen extending far inland on the south of the valley of Glenarif and crowned by the conical summit of Cruach-a-Crue; while on the opposite side of that valley a similar but more lofty ridge terminates in the singular mountain of Lurgethan, which appears as

the frustum of an enormous cone of great height and comparatively narrow base.

Both Cruach-a-Crue and Lurgethan present thick basaltic masses on their summits, resting at considerable elevations on strata of chalk; in the former mountain the lower beds are concealed by grassy slopes, in the latter red sandstone is exhibited in several points towards its central region: here probably a more full examination might detect and ascertain the thickness of the green sand and lias, which from the general structure of the district might be expected to intervene between the chalk and red sand; the spot certainly appears very favorable for such an enquiry.

At the foot of Lurgethan the coast presents two low cliffs divided by a valley which affords a passage towards the sea to a small rivulet; these cliffs are composed of red sandstone and a conglomerate containing rounded fragments of quartz, the rock being altogether similar to that which Dr. Berger has described as the old red sandstone in the neighbouring hill on which Cushendon church is built: since, between these cliffs and the sections visible in the precipices which occur near the summit of Lurgethan, a considerable space intervenes through which the substrata are concealed by grassy or cultivated slopes, it is not easy to determine the geological relations existing between the sandstone in the higher region and that on the level of the sea.

On the most southern of these cliffs near the strand at the mouth of the Glenarif river stand the remains of an old fortification known by the name of Red bay Castle; close to this spot several basaltic dykes traverse the conglomerate, one of these, remarkable for its great thickness, having resisted the action of the waves which have encroached considerably on the adjacent cliffs, presents some bold detached crags projecting from the beach. The conglomerate form-

ing the wall of the dyke has undergone a great degree of induration, its cement assuming the appearance of a compact hornstone; thus it has been enabled to oppose to the sea a resistance almost equal to that of the basalt itself, and is still seen adhering on the sides of the advanced crags above mentioned.

From the most northerly of the two cliffs a ridge extends towards the ascent of Lurgethan on the south-west, running through the townland of Killnadore; in several points along this ridge, and particularly at Nockans and Tully, a very remarkable formation of porphyry may be traced. Dr. Berger* considers it as clinkstone porphyry and describes two varieties here noticed by him; one of them distinguished by a reddish brown and the other by a bluish grey colour, both containing concretions of glassy quartz and of calcareous spar, the latter of which in the first variety occurs in the form of detached crystals, but forms veins in the second. He adds that it crops out in independent masses. He mentions also Court Martin, an old entrenchment near Cushendahl, on the road to Cushendon, as another locality of the porphyry.

From the observations made by Mr. Buckland and myself on these rocks we were induced to believe that they were associated with and subordinate to the old red sandstone. The position of the ridge of Killnadore is distinctly indicated in the section.

On the north of this ridge is the mouth of the river Balyeemin on which the little village known by the double name of Newton

* In an earlier part of the paper it was erroneously stated that this porphyry had escaped Dr. Berger's notice, and the editor did not discover his mistake till the state of the press rendered it necessary to substitute acknowledgment for correction. His oversight arose from the circumstance of its being described among the floetz trap series, though its connection with the old red sandstone and its position near the foot of Lurgethan, while the floetz trap is confined to the summit of that mountain, certainly renders its introduction in such a place an act of very questionable propriety.

Glens or Cushendahl is situated; the loftier ridge of Lurgethan also runs to the west forming a bold amphitheatre of beds skirting the southern bank of that river, and at length joining the still more elevated mountain of Teabuliagh which extends between the confluence of the Ballyeemin and the Glenaan a tributary streamlet. The summit of Teabuliagh exhibits basalt, chalk, and red sandstone; and from hence these formations continue to crown the mountain chain which runs at the distance of about six miles from the sea, while the lower hills which occur nearer the coast are occupied by rocks of much greater antiquity.

Returning to Cushendall and tracing these as exhibited in the section of the cliffs, the old red sandstone and conglomerate (fully described page 149) lines the coast as far as the bay of Cushendon; near its termination at this point it is worn into many grotesque forms, and presents considerable caverns: here Mr. Buckland observed that the cement of the conglomerate often passed from a mechanical to a chemical state, and assumed all the characters of regular clay porphyry of a reddish colour, which appears to indicate the true relations of the porphyry at Killnadore.

On the north of Cushendon point the valley of Glendun is seen penetrating far into the country; through this valley the mica slate makes its appearance underlying the old red sandstone. The mountains in the back ground are a continuation of the secondary range from Teabuliagh and are of similar constitution.

The cliffs of Cushleak ranging from the mouth of the Glendun river to Murloch bay present mica slate, containing subordinate beds of primitive limestone, syenite, and felspar porphyry.

The hills rising above these cliffs, as they approach Murloch bay, become covered with beds of red sandstone and chalk towards their summits, and some of the highest points exhibit caps of

basalt. It is highly desirable that the slopes of these hills should be carefully explored; by examining the channels furrowed in their sides by the wintry torrents, we might hope to ascertain the whole series of rocks here intervening between the primitive formations and chalk.

Murloch bay is bounded on the south by a promontory, which exhibits in the cliffs at its base beds of mica slate dipping towards the north-west under an angle of 45°; but immense slopes of debris (consisting mostly of primitive rocks) interfere to prevent the possibility of determining the structure of the lower regions of the cliff as soon as the bay is entered. Above these slopes red sandstone is seen supporting chalk; the former rock attains the elevation of 560 feet above the beach, the latter extends to the summit of the cliff about one hundred feet higher: between the red sand and the chalk a thin bed of green sand, cementing quartzose pebbles, may be traced. The bed of wackè here occurring in the chalk, has been noticed, page 173, and several whin dykes are observable traversing the red sand. The most remarkable objects on the beach are a large basaltic dyke, which rises in a projecting crag; and still further to the north, near the centre of the bay, the detached conical mount of Drimnakill, which is formed by a vast subsided mass of columnar greenstone, the columns being thrown confusedly together in every possible direction. Near the whin dyke a conglomerate, resembling that of Cushendon, may be seen; so that this rock appears on either side to skirt the primitive formations of Cushleak.

Beyond the mount of Drimnakill, the lower parts of the cliffs are still concealed by slopes of debris, among which subsided masses of columnar greenstone form the prevailing feature; and near this

point bold and lofty precipices of that rock take place of the chalk and red sandstone in the higher region, and, stretching to the north, constitute the well-known promontory of Fairhead, which bounds Murloch bay on that side.

It is greatly to be regretted, that the convulsions of which this bay appears to have been the theatre, having covered the regular strata with shattered fragments and piles of ruin, heaped together in the wildest confusion, have thrown an impenetrable obscurity over its structure, which, from the narrow space in which so many formations are successively exhibited, must be regarded as more important than that of any other point on this coast.

From this cause it is impossible to ascertain the exact relations of the greenstone at this point with the chalk and red sand. The general appearance is, that the mass of greenstone abuts abruptly against that of the sandstone, both being placed at the same level. It has been said that the greenstone and sandstone are here to be observed, alternating with each other. (See notes to the poem of the Giant's Causeway, by Mr. Drummond.) But it may be questioned whether this representation is not founded on a hasty view of some of the subsided masses above mentioned. The greenstone, where it first appears, exhibits two columnar strata, separated by a bed of amorphous greenstone.

Near the point where the greenstone is lost, we observed the traces of adits formerly driven into the sandstone in search of coal, beds of which appear to occur among the lower members of the sandstone formation. The position of one of these adits is such as to afford some countenance to the supposition, that the greenstone and sandstone here alternate; and, since a thin horizontal bed of trap certainly does occur interstratified with the coal measures on the other side of Fairhead, such an opinion cannot be rejected without further examination.

It may be conjectured that the coal measures underlie the greenstone through the entire range of Fairhead, since they again make their appearance beneath it on the east side of the promontory; but the whole of its base is too much encumbered with debris to allow of our ascertaining this point. On the west side, at a lower level than the coal measures, we noticed a ledge of clay porphyry running out to sea; this rock is probably analogous to the porphyries of Killnadore.

The columnar greenstone of Fairhead, and the coal measures which underlie that rock in Gobb cliff, have been already described*, and I have to mention but very few additional circumstances, principally relating to the whin dykes which traverse that cliff; of these dykes, the first in advancing from the east, is Carrick Mawr, "the great crag," a name well deserved by its dimensions: it forms a broad causeway, traversing the beach and terminating in a nearly insulated mass of rocks rising about thirty feet; of this mass only the central line consists of the dyke itself, the sides being evidently composed of portions of the strata traversed by it, but much altered in their character and degree of induration by its contact. These beds appear to have been chiefly derived from the slate clay of the coal measures, which has become so compact as to assume the character of flinty slate. In one point this rock may be seen on one side of the dyke, and on the other the sandstone grit, which usually accompanies the coal beds, also in a highly indurated state: its colour changed from red to white, and its mass penetrated by

* It should be noticed, that in the section all the coal measures are coloured with a dark tint, though this in fact belongs only to the coal itself and to the slate clay; the thick beds of red sandstone which alternate with these strata form the predominating features of the cliff.

This system of colouring has been adopted, becouse it seemed necessary to distinguish the coal measures from the red sandstone not containing coal.

minute grains of iron pyrites. At fifteen yards distance from the dyke the alteration ceases, and the sandstone resumes its usual character, becoming reddish and destitute of pyrites. Where the dyke traverses the great insulated mass of slate, it is very irregular both in thickness and direction. The works of Gob colliery have reached this dyke 500 yards inland from the face of the cliff: the coal is altered by it to a considerable distance from its point of contact, being reduced to the state of a cinder, which can be employed only for burning lime. This dyke throws out the measures of Gob colliery, which are not recovered on its eastern side: its breadth is about 12 feet where it comes to the surface of the cliff, but varies considerably in different parts of its course.

Immediately behind Carrick Mawr, an opening may be seen in the cliff which forms the channel of a torrent; pursuing this inland for the distance of about a mile it is found to issue from a small lake surrounded with basaltic cliffs. We were ourselves prevented from visiting this spot, but from the descriptions we received of it were led to wonder, that none of those who consider this country as volcanic had selected it as a crater.

At some distance east from Carrick Mawr dyke is the Saltpans dyke, which also throws out the coal of Gob mine on the west; its breadth is eight yards. Still further is a thin dyke; both these alter the coal. North Star dyke follows. This is often cut through in the collieries, its breadth is eight yards: it does not shift the coal, but reduces it to cinder for nine feet on each side of its contact.

Where the cliff declines towards Ballycastle, the coal measures terminate abruptly, and are succeeded by trap rocks. It seems that this position must have been produced by a fault and subsidence.

Near Ballycastle a broad valley opens into the interior to-

wards the south and east. This valley is principally occupied by the red sandstone, which, in those directions terminates against the mica slate, forming the base of Knocklead (the round-backed mountain seen in the distance) and extending thus far in continuation of the primitive district already described in Cushleak. Between 4 and 500 feet on the ascent of this mountain, a bed of primitive limestone may be traced. Above this, through an interval of about 400 feet, the strata have not been ascertained; but probably the red sandstone, and perhaps also the lias and mulattoe, may be found in this space, since the chalk appears at the elevation of between 8 and 900 feet; and the whole is crowned by a cap of basalt, 980 feet in thickness.

On the eastern side of Ballycastle bay, the basalt rises into low cliffs, and the substratum of chalk emerges from the level of the sea, but soon sinks again.* In this interval the vein of wacke and compact limestone, described by Dr. Berger, page 172, occurs; from hence to Kenbaan there is nothing that requires particular attention.

* I cannot more clearly describe the general arrangement of the chalk and basalt, as displayed on the Antrim coast, than by transcribing the following paragraph from the late Mr. Hamilton's Letters, a work which may be classed with Mr. White's well-known letters on the Natural History of Selborne, as one of the most elegant models which our language possesses of writing upon such subjects; and as affording one of the few examples which prove that they are capable of being treated in such a manner as shall render them not only interesting to the enquirer into the detail of science, but engaging to the man of general information and cultivated taste.

"The northern coast of Antrim seems to have been originally a compact body of limestone, (chalk) considerably higher than the present level of the sea; over which, at some later period, extensive bodies of vitrifiable stone have been superinduced in a state of softness. The original calcareous stratum appears to be very much deranged and interrupted by these incumbent masses. In some places it is depressed greatly below its ancient level. Shortly after it is borne down to the water's edge, and can be traced under its surface: by and by it dips entirely, and seems irrecoverably lost under the superior mass. In a short space, however, it begins to emerge, and after a similar variation recovers its original height."—Letters on the Coast of Antrim, page 5.

Of this interesting spot it is hoped that the general section, and the views in Plate 11. fig. 2. will convey an accurate conception.*

* Desiring to keep that description of facts which must serve as the ground-work of theory, and which seems, in the present state of science, the most useful employment of the geologist, distinct from conclusions merely speculative, I have hitherto studiously refrained from expressing the views which I have been led to form on the origin of basalt, and of the other rocks usually associated under the general name of flœtz trap.

But while describing the striking appearances presented by Kenbaan cliffs, I cannot forbear to declare the conviction which this spot first impressed upon my mind, and to express my full assent to the arguments of those who maintain the igneous origin of such formations.

I would observe then that this formation is distinguished by characters so directly opposed to those which all rocks undoubtedly of aqueous origin possess, that no hypothesis which ascribes both to a common origin, can be otherwise than contradictory, and at variance with itself. For

1. Of all other formations, the least ancient are the least elevated; but this, the most recent of all, yet rivals the primitive mountains in height.

2. Of all other formations, the degree of consolidation decreases together with its age, their texture passing from crystalline through the several gradations of sub-crystalline, compact, coarse, and lastly earthy; while in this formation, even where it rests on chalk, the crystalline texture of the oldest rocks frequently recurs.

3. Whin dykes, which are indisputably connected with this formation, differ from all other mineral veins, in the circumstance of their traversing all rocks indifferently; while of other veins, particular classes are exclusively associated with particular rocks.

Such being the negative evidence against the Neptunian hypothesis, I proceed to that which is positive in favor of the volcanists; as

1. The identity of chemical composition in basalt and lava.

2. The constant occurrence of trap rocks in volcanic districts.

3. The confession of the Wernerians themselves, that the basalt of Auvergne is of igneous origin.

4. The testimony of those best acquainted with districts still exhibiting active volcanoes. Such persons, as Dolomieu and Spallanzani, have uniformly maintained the igneous origin of basalt, while those who have contended against it have generally been unacquainted with countries of this description.

Having thus alluded to, rather than stated, some of the general arguments on which this question appears to me to depend, I return to Kenbaan, where the basalt is seen extending from beneath as well as overlying the great mass of chalk, which has at one extremity assumed such a curvature as would naturally result from lateral pressure; and at the other is rent, and shattered in the most extraordinary manner, the basaltic matter

A mass of chalk, extending about a furlong in the face of the cliffs, is here seen, terminated abruptly, and with every appearance of violent convulsion at both extremities. Towards the east it is underlain as well as overlain by basalt, and loses itself, forming a narrow tongue surrounded by that rock. In this quarter a portion of the chalky strata, elsewhere horizontal, exhibits a remarkable curvature. Towards the west the chalk runs far out to sea, forming a sharp and narrow point of land, of which the greatest height is about 70 feet. The isthmus which joins this point with the main land, is

insinuating itself into the fissures, and often converting by its contact chalk into granular marble, while fragments of the chalk, of all sizes, appear to have been forced upwards and imbedded in the basaltic rock, having suffered in their superficial parts where the basalt touches them a most remarkable change.

It seems impossible to conceive appearances more utterly irreconcilable with the hypothesis, that the basalt was deposited regularly above the chalk from a state of aqueous solution. On the other hand, were we to imagine a priori, the phenomena which would probably result from the eruption of a current of ignited lava from beneath the chalk, and its subsequent diffusion over the upper surface of the chalk, while the whole was submerged beneath the sea, and under a considerable pressure, they would exactly accord with those which may actually be observed at Kenbaan.

To the same purpose the changes effected by the whin dykes of this district on the rocks they traverse might be cited. Thus we have instances:

1. Of the conversion of old red sandstone to hornstone. See page 201.

2. Of the conversion of the slate clay of the coal measures to flinty slate, and of the reduction of the coal itself to cinders. See pages 205, 206.

3. Probably, also, of the conversion of the slate clay of the lias formation into flinty slate. See page 213.

4. Of the conversion of chalk in several places into granular marble. See pages 172. 173.

Hence, if it be allowable to speculate on subjects so remote from actual observation, I would infer that the hypothesis which ascribes the formation of the flœtz trap rocks to submarine volcanoes, which were active at a very remote period before the seas and continents had assumed their present relative level, is both in itself more consistent, and in its application to the actual phenomena more satisfactory than any other.

It is evident that the basaltic mass of Ulster was accumulated antecedently to the last great convulsion which has modified the surface of our globe, excavating its vallies, and constituting its alluvial deposits.

completely broken through. The ruins of an ancient tower rise above this chasm, on the sides of which the course of an enormous whin dyke may be traced; and the whole promontory is shattered in every direction, masses of basalt (sometimes mingled with chalky debris and flints) protruding through numerous fissures. The chalk, where it comes into contact with these dykes, is often converted into a compact and crystalline marble.

The mass of chalk just described is covered by thick beds of basalt; but near the top of the cliffs, which here rise about 300 feet, are seen two other beds, which viewed from a small distance appear to be chalk, one rising to the surface above the western, and the other above the eastern extremity of the inferior chalky mass. These, on nearer examination, appeared to be a breccia composed of fragments of chalk, of various sizes, intermixed with flints and basaltic concretions. The outer surfaces of these fragments are much altered, and they are penetrated by small nests of a greenish substance appearing to be steatite, the interior presenting the chalk in its usual state.

The opposite coast of the island of Rathlin exhibits, as will be seen by the section of it in Plate 10. an exact analogy to that of the main land; and on that point of it lying directly over against Kenbaan head, a singular combination of dykes occurs, seeming to be continuations of those which at the latter place appear to have been attended with such extraordinary disturbances. Here, within the distance of 90 feet, three dykes may be seen traversing the chalk, which is converted into a finely granular marble, where contiguous to the two outer dykes, and through the whole of the masses included between these and the central one: these dykes are situated a little to the west of Church bay, they are marked in the section Plate 10; and a ground plan, on a larger scale, is added in Pl. 11. fig. 2. representing their appearance as traced upon the beach.

Carrick-a-rede is the next remarkable headland to Kenbaan. Between these promontories the chalk twice rises above the level of the sea, and as often sinks beneath it; the strata exhibiting evident marks of dislocation, and either of elevation or subsidence.

Carrick-a-rede is an insulated crag of rudely prismatic basalt; the dangerous rope bridge thrown across to connect it with the mainland by those engaged in the salmon fishery, has rendered it celebrated.

Beyond Carrick-a-rede the limestone again rises, is traversed by some whin dykes and near Sheep island forms a cliff about 100 feet in height. Here a large detached basaltic rock rises close to it on the beach, appearing to have been brought by subsidence to the same level, and to a parallel position. The same remark may be extended to Sheep island, itself a basaltic mass.

Above these cliffs are seen the lofty basaltic hills of Knocksoghey and Croaghmore, where are the columnar strata mentioned in page 183; the wood coal described in page 188 also occurs in this neighbourhood, close to the village of Ballintoy, of which the spire is seen forming a conspicuous land mark.

The chalk suffers a partial interruption, attended as usual with dislocation of the strata, near Ballintoy, but again rises to considerable height on the sloping ground which skirts White Park bay. In a valley near Ballintoy, the inferior limit of the chalk is exposed, and a substratum of a bluish slate clay, containing gryphites and ammonites, (apparently the same which alternates with the lias near Glenarm) is laid open. The chalk is abruptly broken off on the east of White Park bay, in a little cove called Port Braddin. Here the basalt abuts directly against the chalk, and that arrangement of strata, so well known as constituting the mag-

nificent range of promontories in the neighbourhood of the Giant's Causeway, commences. Since the chalk, which is here placed on the same level with the highest of these strata, must certainly in its regular place occur beneath the lowest, and since the whole series has been ascertained considerably to exceed 400 feet in thickness, the subsidence of the basaltic mass at this point must have been very great.

The neighbourhood of the causeway, with all its remarkable features, its superb storied façades, distinguished by a double order of columns, its whin dykes and its caverns, have been so fully and ably described by Dr. Richardson in the Philosophical Transactions, that they are already familiar to every reader interested in such subjects. His list of the strata here ascertained has been already given, page 177. On the strand near the mouth of the Bush, are two parallel ledges of chalk and basalt.

The appearances of the cliffs between Bushfoot Strand and Portrush Strand, are so similar to those which we have already found frequent occasion to notice, that this part of the section does not appear to require further elucidation. Near the termination of the chalk cliff on the west, a very inexplicable phenomenon presents itself; a large spherical mass of basalt, appearing to be completely enveloped in the chalk.

The singular peninsula of Portrush demands more particular attention; a long line of strand separates it on either side from the cliffs which rise at about the distance of a mile to the east and west.

The peninsula itself, which may be about a mile in circumference, is fenced with low cliffs on the west, north, and east; those on the west present a rudely prismatic greenstone; those on the north and east tabular masses of greenstone, overlying, and in

some places appearing to alternate with, a very remarkable rock which has been the subject of much discussion among the supporters of opposite theories.

It is a flinty slate, exactly similar to the indurated slate clay which forms the wall of the Carrick Mawr dyke, in the Ballycastle collieries; and the analogy is rendered the more striking, from the further resemblance of the greenstone of that dyke to the greenstone of these cliffs. In this flinty slate are contained numerous impressions of cornua ammonis invested with pyrites, the shells being similar to those found in the slate clay underlying the chalk near Ballintoy.

The advocates of the Neptunian theory consider this rock as a variety of basalt, and refer triumphantly to its included fossils, as affording a conclusive argument against the Volcanists.

Professor Playfair, on the other hand, expresses his belief that "the rock containing the shells is the schistus or stratified stone, which serves as the base of the basaltes, and which has acquired an high degree of induration by the vicinity of the great ignited mass of whinstone." See illustrations of the Huttonian theory.

The resemblance of this rock to the indurated slate-clay of Carrickmawr, and the identity of its fossils with those of the slate-clay underlying the chalk near Ballintoy, together with the relative position of Portrush and of the chalky cliffs on the east, appeared to us to give the greatest weight to this very ingenious conjecture; and we felt convinced while examining the spot, that the rock was no other than the slate-clay of the lias formation in an indurated state.

The remaining portion of the section will sufficiently explain itself: it terminates where the secondary formations turning to the south finally quit the coast. The headland of Macgilligan, the most northern point of the mountain range formed by their escarpment

in the west of Derry, is seen at the distance of three miles inland; it is remarkable for the grandeur of the scenery presented by its shattered precipices.

Of the island of Rathlin or Raghery, the section represents only the cliffs extending from its most westerly promontory to the centre of its southern line of coast. From the point where the section terminates, the precipices round the southern cape and the eastern and northern shores are exclusively composed of basalt, and frequently present columnar groups. (See page 182.)

To the conjecture of Dr. Berger, however, that sandstone and older rocks exist at no great depth in the south-eastern quarter of the island. (See page 151.) the positive assertion of Mr. Hamilton must be considered as adding great weight. "An heterogeneous mass of freestone, coals, iron ore, &c. which forms the east side of Ballycastle Bay, and appears quite different from the common fossils of the country, may be traced also directly opposite running under Raghery, with circumstances which almost demonstrably ascertain them to be the same veins." Letters on the coast of Antrim, page 8.

From the exact correspondence in structure between the opposite points of coast upon this island and the main, Mr. H. infers that "Raghery standing as it were in the midst between this and the Scottish coast may be the surviving fragment of a large tract of country, which at some period of time has been buried in the deep."

The pebbles of sienite which are scattered over various parts of this island, and must have travelled hither from Cushleak, concur to prove the later formation of the channel now separating it from the mainland. Dr. Mac Culloch observed appearances analogous to these in the island of Staffa, and deduces from them the same conclusion. See Transactions of the Geological Society, Vol. II. page 207.

The facts stated in the introduction to this paper (see pages 123, 125.) are of such a nature as leave no doubt in the mind of the writer, of the former continuity of the Irish and Scotch coasts.

The greatest depth of the channel between Rathlin and Antrim is 53 fathoms, and between the north-east of Ireland and south-west of Scotland 90 fathoms.

It now only remains to explain the principles followed in the construction of the geological maps accompanying this paper.

The larger of these comprehends the whole of the district which has been described, as it is limited, in the Introduction, page 121.

Much attention has been bestowed on the delineation of the mountain chains; the heights of the principal summits are inserted from Dr. Berger's measurements.

The more important soundings on the coast are added.

In a map on so small a scale it was not found practicable to distinguish every minute formation by different colours; it became therefore necessary to assume as the basis of the colouring, the prevailing rocks which, in association with other subordinate formations, constitute districts of considerable extent.

Thus the districts to which separate colours have been assigned, are

1. The granitic district of the Mourne mountains, &c. The hornblende or primitive trap rocks, on the border of this district, are distinguished by an appropriate mark.

2. The mica slate districts of Londonderry and Antrim, including primitive limestone, felspar, porphyry, and sienite, each distinguished by peculiar signs.

3. The transition district, encircling the Mourne mountains. The lead mines in this district are marked.

4. The shell limestone underlying the coal.

5. The sandstone district, of which the lower beds are associated with the coal, and the upper with gypsum. The collieries are distinguished by black circles.

6. The zone formed by the basset of the chalk round the escarpments of the mountain groupe, which forms our third system. It was not possible to insert the lias and greensand intervening between the sandstone and chalk; but their localities are fully indicated in the paper and in the sections.

7. The great district of floetz trap.

The smaller map, Pl. 9, exhibits a general outline of the opposite points of Scotland and Ireland, intended to shew the connection between the principal formations in each country, as pointed out in the Introduction. The colours represent.—1. Granite. 2. The mica slate district of the Grampians, and the northern chain in Ireland. 3. The transition district of the Lead hills in Scotland, and of Down in Ireland. 4. The secondary rocks associated in the coal district. 5. The floetz trap districts.

ELEVATIONS OF SEVERAL STATIONS

IN THE COUNTIES OF

LOUTH, ARMAGH, DOWN, ANTRIM, AND LONDONDERRY,

Calculated from the Level of the Sea by Barometrical Measurement,

BY DR. BERGER,

County of Louth.

		FEET.
1	Highest part of the road between Dundalk and Newry, by Jonesborough	283¼
2	Barensdale mountains, highest part of Lower Dundalk Barony	1644
3	Foy mountain; the highest of the Carlingford mountains	1850
4	Golding mountain; Mountain town? lower ridge of Carlingford mountains, (Cooley mountain of M'Kenzie?)	1055

County of Armagh.

		FEET.
1	Fathom mountains; the highest part of, along the Newry River	820
2	Cum-Lough; between Slieve-Gullen and Slieve-Girkin, or Newry mountains . . .	305
3	Killevy or Kilsleve-Church, at the base of Slieve-Gullen, on the south-side	503⅓
4	Slieve-Gullen	1900
5	Slieve-Girkin or Newry mountains . . .	1340
6	Faughell or Foughall mountains, a little to the north-east of Jonesborough . . .	822¼

	COUNTY OF DOWN.	FEET.
	MOURNE MOUNTAINS.	
	† LOWER IVEAGH.	
1	Rosstrerve-hill, at a large block of granite not quite to the top of the hill	865
2	*Lough-Sally?* at the entrance of a peaty circus (Deer's Meadow?) situated at the foot of the Mourne mountains to the south . . .	421
	Lough Shannagh; on the slope of Slieve Muck .	1265
3	Slieve Muck	2290
4	Slieve Snaven (Slieve Birna?)	2370
5	Bingan mountain (Brem Buncin?) . . .	2396
6	Slieve Donard	2654
7	Newcastle Slate quarry; on the acclivity and	
8	towards the base of Slieve Donard . .	191
	Dundrum lead-mines	281
9		
	†† UPPER IVEAGH.	
10	Clark-hill, Slieve Slut? within (referred to *Castlewellan)* the demesne of the Earl of Annesley	548
11	Slieve Anisky	170
12	Bakaderry town, near a cross bearing the date 1675	369
13	Slieve Croob	1204
	††† ARDS.	
14	Temple of the winds; Mount Stewart . .	113
15	Captain Allen's fort, (Black Abbey?) one of the highest spots across the peninsula of Ards, near B. Atwood	140⅔
16	Windmill of B. Neboly	167
17	Conlig-hill Bangor	473
	†††† CASTLEREAGH.	
18	Scrabo-hill	483
19	The watershed between Strangford-Lough or L. Cone and Belfast Lough, not far from Kirk Donnel	263⅓

	COUNTY OF ANTRIM.	FEET.
1	Dirris mountain, Belfast	1475
2	Doon ravine, or Allan's Ravine, upper part, Belfast	531
3	Cave hill, Belfast, upper line of the white limestone	768
4	Mc Arth Forth : Cave-hill top	1064
	Thickness of the cap of trap	295
5	Squire's-hill, Belfast	1170
6	Rumbling-hole, upper part of, Collin's Glen	545
7	Black Mountains ; Belfast	1040
8	Watershed of the road between Belfast and Antrim	997½
9	Ditto, referred to Lough Neagh	865
10	Hence elevation of Lough Neagh	132½
11	Glenery Church, referred to Lough Neagh	170
11	The same referred to the sea; (more problematical)	302
12	Drumadaragh, or Ballyroy-hill, *above Doagh*	660
13	Sandy Brae hill, *above Doagh*	537½
14	Slemish Mountain, *above Broughshane*	1130
15	Carnybuy ? highest part of the road between Coleraine and Bushmills	527½
16	Cliff by Dunluce-castle	157
17	Orbilt ? (Dunmull top)	463
18	Cape Pleaskin : from two observations	354,8
19	Bengore-head, from two observations	328,3
20	Clogher ; a little to the north-east of Bushmills	130⅓
21	Craig-park, to the south east of Bushmills	304
22	Ballychra-crafey : townland of Glenstiaghey	530
23	Cliff (of chalk) facing Sheep island	130½
24	Croaghmore, near Ballintoy	471⅔
25	Cross-hill, (B. Castle Collieries) upper line of the freestone	363¾
26	Cross-hill, top	508⅓
	Thickness of the cap of trap	144,4
27	Fairhead top	535
28	Murloch, upper line of the red freestone	560
29	Murloch, limestone cliff	652½
30	Benvaan top, near Murloch	855
31	Coolnagopag, or Carnanmore, near Murloch, from two observations	1130
32	Knocklead top	1820
33	Cloughamurry town-land, an acclivity of Knock lead, upper apparent limit of the granular and micaceous limestone	493
34	Cape Castle : on an acclivity of Knocklead : upper apparent limit of the white limestone	840

	COUNTY OF ANTRIM.	FEET.
35	Ballydurnian: on the acclivity of Knocklead: upper apparent limit of the white limestone .	895
36	Munnanacloick, on the acclivity of Knocklead; upper apparent limit of the white limestone .	920
37	B. Patrick, upper line of the white limestone .	622
38	B. Patrick, top	955
39	Breen, a swampy ground, main feeder of the bush R.	762½
40	Ardagh: level of the Glenchesk R. . .	797
41	Highest part of the old road between B. Castle and Cushendun	945
42	Middle Cushleak: lower line of the white limestone	695
43	Doon-a-rary Castle	236
44	Oona, habitations in the valley of Glendun .	590
45	Beagh habitations, Glendun valley . . .	367½
46	Beagh mor	974
47	Glendun: upper apparent limit of the white limestone	885
48	Slieve-Nory, top	1530
49	Upper limit of the white limestone at Aghan, Oona mountain	882½
50	Teabulliagh: upper line of the white limestone .	735
51	Teabulliagh mountain top	1235
52	Cliff above the caves of Cushendun, called Cranagh	123½
53	Teavuagh; by Cushendall Church . . .	522
54	Slieve-Cross; highest ground between Cushendun and Cushendall, on the right of the road .	742½
55	Highest part of the Shore-road, between Cushendun and Cushendall	610
56	Craig Rammer mountain; a little to the north-west of Cushendall	559
	† ISLE OF RATHLIN, OR RAGHERY.	
57	Slieve Ard	372½
58	Cligan Lough	238
59	Kinrammer-head	352½
60	Bull-point	280
61	Sliebh-an-all	347½
62	Kintwan-head	318¼
63	Altahorry point	83½
64	Crook-a-harnane	104½
65	Ushet Lough	144⅔
66	Drimnagrulligh	228⅓
67	Broagh-mor-na-hoosid	234⅙
68	Slieve-na-varagin (the rocky-hill?) . . .	93⅓
69	Slack-na Calye Cliff	240

	COUNTY OF LONDONDERRY.	FEET.
1	Moneymore	183¼
2	Mayola R. bridge; nearly half way between Cookstown and Dungiven	414
3	Highest part of the road from the bridge on the Mayola R. to Dungiven	1177
4	Cragnashoack-hill (the Hawk's-hill); the upper line of the sandstone	1589½
5	Cragnashoack mountain: top	1864½
6	Dungiven	447
	The three following heights were *directly referred to Dungiven*, and thence calculated above the level of the sea.	
7	Benbradagh-hill; upper line of the sandstone .	903½
8	Benbradagh-hill; upper line of the white limestone	1266
9	Benbradagh top	1569½
10	The Glebe-house of Garvagh	440
	The eight following heights have been referred directly to this spot, and thence calculated above the sea.	
11	Broka-bhoy: a swell of gravel-rag on the slope of Coolcoscrehan mountain	710
12	Coolcoscrehan mountain top	1292½
13	Dunavenny brook; a feeder of Allen water, being the first appearance of the primitive formation on the slope of Cairntogher . .	718
14	Cairntogher mountain top	1600
15	A swampy ground on the south side of Cairntogher; the head of several rivers . . .	1090
16	Donald hill: upper line of the sandstone . .	900
17	Donald hill top	1399
18	Ballyness limestone quarry: upper line of the limestone	717½
19	Down-hill: mausolæum of the late Lord Bristol.	255
20	Benyavenagh mountain towards Magilligan point, a complete mass of stratified trap. (rating the limestone at 80 feet.)	1145
21	Cady-hill; upper line of the white limestone .	604
22	Cady-hill top	1030
23	Watershead of the road between Coleraine and Newtown-Limavaddy	885

	COUNTY OF LONDONDERRY.	FEET.
	Many of the following mountains belong to the county of Tyrone, as well as to that of Londonderry; since they limit the two counties.	
24	Banagher Church	508½
25	Mullaghash mountain top	1677
26	Sawell mountain top	2257
27	Knocken Bann; Monterloney: the highest cultivated ground I have seen in the North of Ireland. Crop of oats *	918½
28	Fin-Glen or Fion-Glen mountain top † . .	2097
29	Moneynieny; the mountain of wonders . .	1477
30	Sphell-Cooagh: the Cuckoo's mountain . .	1867
31	Dunlogan-hill; an appendage to Sphell-Cooagh .	1467
32	Ben-Bhoy	1220
33	Ch. o'Hagan's Inn: from Mayola bridge to Dungiven	338
34	Lough Faë or Finea; on the west side of Slieve Gallion mountain	767
35	Highest ground on the road between Cookstown and the Mayola bridge	841
36	Upper line of the limestone on Slieve Gallion .	1459½
37	Tamach; highest part of; Slieve Gallion . .	1624½
	The thickness of the limestone formation is but very inconsiderable	
38	Cumber-Clady: Mr. James Ross' house: Faughan valley: from two observations . .	260½
39	Lesstress-hill; by the waterfall of Ness . .	660
40	Malabwea-hill	850

* They were ripe, and some had already been cut on the 20th September, 1811.

† This and the five following heights were referred, as before, *directly* to Dungiven.

IV. *On the Dykes of the North of Ireland.*

By J. F. Berger, M.D. Member of the Geological Society.

Read November 4th, 1814.

My object in the following paper is to describe some of the more general characters of Dykes, such as I have lately observed them in the North of Ireland.

I do not know exactly within what geographical limits these curious geological phenomena are to be met with: they are common on the Western coast and in the Isles of Scotland, and I have observed them also in the Isle of Man. I understand that none have yet been remarked in the South of Ireland, and I did not observe any in the Midland counties through which I passed between Dublin and the Northern coast. In England they have been found in the centre of the island, as at the colliery of Tividale in Staffordshire; but in the North of Ireland it is only on the verge of the coast that they abound, and it is there that I have principally examined them. Of more than sixty that I noticed, nearly half were situated on the shore; those which occur in the mountains of Donegal are I believe the remotest from the sea, and those lie within fifteen miles of it.

I have not found their occurrence to depend upon the absolute elevation of the country in which they appear. I have observed them at almost every altitude between that of the shore and those which I have inserted in the following Table, as being the greatest and somewhat uncommon.

		Feet
1.	Dyke on Cave-hill, West of Belfast Lough on the Antrim side, above the sea	1064
2.	Ditto on the top of Ballyghuia Cupola, Kilmacrenan, Donegal	1448
3.	Ditto near the top of Aghla mor, Boylagh, Donegal	1726
4.	Ditto near the top of Glendoan, Kilmacrenan, Donegal	1738
5.	Ditto on the top of Glencarn mountain, Boylagh, Donegal	1745
6.	Ditto near the top of Arragh, the highest mountain in Donegal N.W. side . .	1848
7.	Ditto . . . . . South side . .	2220

It seldom happens in the North of Ireland that dykes occur singly; but they are generally found in groups, several within a short distance of one another. Thus, at the Giant's Causeway there are 6 within 2 English miles; at the collieries of Ballycastle 5 within the same distance; at Alt-a-dora (a glen in the valley of Dunlughy) 4 within 1 mile; on the N. W. side of Arragh, 6 within 1042 feet; and at Church home in the basin of Dunlughy, 4 within 835 feet.

The uniform direction or parallelism of nearly all the dykes in the North of Ireland is a curious circumstance resulting from my observations: I have subjoined a list of all the dykes that I surveyed with accuracy, in order to put the Society in possession of the data from which I have drawn this conclusion. Many of those in the table were surveyed with a theodolite, others with a very good pocket compass mounted on agate; in all the latter cases I have allowed for a variation of 29° West, upon the authority of Mr. Hanton of Loch-beg in the Rosses, who made two observations at my request in order to determine the point. I have rejected from this table the bearings of all the dykes, which I observed with only a common pocket compass, as not having any pretensions to accuracy; and among these the bearings of the famous dykes of the Giant's Causeway; had all however been admitted, they would all have tended to establish the above-mentioned conclusion.*

* The direction of the two dykes at the colliery of Tividale in Staffordshire, is also from S.E. to N.W.

	Locality	Direction of the Dyke W. of N.	Stratum traversed	Direction of stratum E. of N.	Angle at which the Dyke cuts the stratum
1	Far-Dunlughy, Donegal	21°	Primitive blue limestone	51°	72°
2	Church-home Dunlughy, Donegal	17°	Gneiss and primitive granular limestone	55½°	72½
3	Ditto	41°			96½
4	Ditto	27°			82½
5	Ditto	34½			90
6	Mein-a-bole, N.W. side of Arragh, Donegal	71	Bluish white limestone	12½	83½
7	Ditto	38			50½
8	Ditto	48			60½
9	Ditto	37			49½
10	Ditto	63			75½
11	Ditto	52½			65
12	Ditto	44			56½
13	Ditto	46			58½
14	Ditto	45			57½
15	Ditto	35			47½
16	Alt-na-Calge Dunlughy	31	Talcose limestone	54	85
17	Ditto	31½			85½
18	Ditto	22			76
19	Rannagh Point, Isle of Arran-mor, Donegal	20	Sienite		
20	Pool-a-Phuca, Church-hill, Fermanagh; lesser dyke South limb	53	Limestone with madrepores	89	142
21	Ditto, North limb	31			120
22	Ditto, great dyke	35			124
23	Lough-na-Croey, Stranaglogh mountain, Donegal	49	Primitive limestone	41	90
24	Dunbeg, Giddore, Donegal	19	Sienite		
25	Aghla-mor, Boylagh	39	Slaty quartz	71	110
26	Trayenagh Bay, Rosses	19	Sienite		
27	Ditto	24	Ditto		
28	Lough Foyle, between White and Red Castle	49	Sandstone	16	65
29	Tory	41	Porphyritic sienite		
30	Ditto	18			
31	Ditto	35			

The conclusion to be drawn from this table is that the bearing of the dykes is from S. E. to N. W., and that the dykes all cut the planes of the strata through which they pass, at very considerable angles.

A shift in the direction of a dyke is an accident of rare occurrence; it would probably however be more frequently observed, did not the soil, which covers the surface, prevent us from tracing the dyke to any distance.

The most considerable shift that I ever observed was at Rannagh Point in the Isle of Arran-mor, where it was not less than 47° in 126 feet. At Muir-a-Bole on the N.W. side of Arragh, I observed two other considerable shifts; the one of 22°, the other of 27°.

Dykes differ greatly from one another in their widths, which measure from a few inches to several hundred feet. The latter dimensions are of rare occurrence, and I have only met with three cases of the kind, all in secondary strata; and in two of these the enlargement took place at the bottom of the dyke. One is found in the red bay of Cushendall; the other at Pool-a-Phuca in the county of Fermanagh. The third case occurs between Portrush and Dunbar Castle on the coast of Antrim, and has been noticed by Dr. Richardson. I think I have ascertained that there is a remarkable difference in the average widths of the dykes, according as they are found in primitive or secondary rocks. Out of sixty-two dykes that I have measured, the average width of thirty-eight in the primitive districts is 9 feet; that of twenty-four in the secondary is 24 feet.

I have already noticed some of the more remarkable elevations at which dykes have been found. The height to which a dyke rises above the surface of the stratum, which it intersects, is some-

times very considerable. That on the N.W. side of Arragh rises perpendicularly 40 feet, like a partition wall; that on the cupola of Bally-ghuia 8 or 10 feet; at Scrabo Hill near Newtown Ards in the county of Down a dyke appears like a standing pillar at the entrance of one of the freestone quarries. The dyke of Port-na-brock near the Giant's Causeway, juts out into the sea quite isolated to the visible extent of 372 feet. On the contrary, those on the summits of Glendoun, Glencarn, and Aghla-mor, appear like strewed masses, scattered about upon the surface. These might be adduced as instances to prove the wearing away of mountains, if that point stood in need of any additional confirmation.

The depth to which the dykes descend is unknown; and after having observed the sections of a great many along the coast in cliffs from 50 to 400 feet in height, I have not been able to ascertain (except in one or two cases) that their sides converge or have a wedgeform tendency; so that no estimate can be formed of the depth at which they terminate. In this respect therefore they do not seem to agree with the metallic veins.

Moreover, I have not observed that they branch off into slender strings, or (except in some very rare instances) that they swell into (what the miners term) bellies, after the manner of the metallic veins.

The dykes, whether they occur in primitive or secondary countries are nearly vertical. The mean angle of deviation from the perpendicular deduced from nine cases occurring in primitive rocks was 13°, the extremes being 9° and 20°. The same angle deduced from ten other cases was 7° to the N.E. But I am not warranted in drawing any general conclusion as to what point of the compass and in what degree they deviate. The angle of deviation in the two remarkable dykes on Arragh mountain is somewhat consider-

able, as is also that of the dyke in the quarries of Scrabo hill; but I am not able to state it with precision.

There is not that variety in the substance of the dykes, that their numbers, their distance from one another, and the varied nature of the rocks which they intersect would lead one to expect. I have found them composed of the following rocks, which are introduced in the order of their most frequent occurrence. Trap and greenstone, with their associates Lydian stone, flinty slate, greystone and wacke.

I have seen but one dyke of clay porphyry, viz. at Farland point in Donegal, and I conceive it to be altogether of a different class from those dykes to which my principal attention has been given in the present paper.

A dyke is formed either of a number of diminutive pillars aggregated together, or of square rhomboidal pieces piled one upon another like blocks of masonry, the long axes of these figures in either case lying transverse, and perpendicular to the walls of the dyke. These regular figures are often much disintegrated and rounded, and sometimes assume the coated form; the two appearances being often united in the same portion of rock.

Dykes are not, like metallic veins, divided into regular layers of different stony substances; nor do we find in them those drusy cavities which sometimes occupy the middle of metallic veins.

The more compact the trap, the more apt is it to assume the polyhedral form, to be homogeneous, and to be free from the porphyritic texture. In the hard variety I never found imbedded any detached mineral concretions, except a few small specks of soft green steatite. When less compact, it is often set more or less thickly with heterogeneous nodules, but seldom so abundantly as to

assume a texture decidedly porphyritic. Among these nodules I have found the following minerals.

	Minerals found imbedded in Dykes.	Locality.
1	Augite in angular fragments . . .	Isle of Islandowey.
2	Olivine in disseminated grains . .	Glen of Alt-a-dara in the valley of Dunlugby
3	Crystallized glassy felspar . . .	Glen of Alt-a-dara.
4	Compact felspar in distinct rounded concretions.	
5	Radiated zeolite	N.W. side of Arragh, highest dyke but one.
6	Green soft steatite, in distinct concretions.	
7	Iron pyrites.	
8	Calcareous spar.	
9	Carbonate of lime, mixed with the trap	On the shore on the Antrim side of Belfast Lough.
10	Glassy quartz in distinct concretions.	
11	Sulphate of barytes.	
12	Plates of mica.	

The mean specific gravity of the trap rocks forming dykes may be rated at about 2.86. That of the specimens from Alt-a-dara, containing olivine, being 3.14; that of homogeneous trap from the dykes of the Giant's Causeway being 2.99; and that of the wacke from the shore at Carrick-fergus being 2.45.

The dykes are found traversing both the primitive and the secondary rocks, nor have I ascertained in which they are the most frequent. There appears to be no regular connexion between the substance of the dyke and the rock through which it passes. I have however sometimes found lime in considerable quantity in the dykes that traverse limestone. Glassy felspar I have only found in the dykes of primitive rocks.

In the table of the observations of the dykes some of the rocks cut by them are enumerated; I have added however another table

of the rocks that I have seen intersected, with some additional localities.

Rocks cut by Dykes.	Localities.
Primitive limestone	Vide former list.
Sienite	Newry, Bloody Farland, &c.
Slaty quartz	Farland point, Donegal.
Mica slate	Kildrim lead mine in Donegal.
Gneiss	
Transition limestone *	Blockhouse Isle, entrance of Carlingford bay.
Old red sandstone	Near Newton Glens.
Floetz limestone alternating with sandstone and underlying the coal.	East of Bally-castle.
Coal measures.	East of Bally-castle.
Chalk	East of Glenarm, where the limestone is rendered hard and crystalline in contact with the dykes. One of the dykes branches and encloses portions of the limestone, and many other places, see page 172.
Flœtz trap, basalt†	Giant's Causeway, and many other places.

The induration which the secondary rocks undergo when traversed by dykes has often been noticed; it is not my intention now to discuss this subject; I shall only mention that the induration does not extend far from the dyke, and that the phenomena though very frequent are not universal.‡ I have only noticed one instance of remarkable change in a primitive rock contiguous to a dyke. In the case I allude to, viz. in the lead mine of Kildrim in the county of Donegal, mica slate adjacent to the dyke had its texture quite loosened, and was in a dusty state.

* A dyke also traverses transition limestone, containing magnesian limestone, at Scarlet point in the Isle of Man. † Inserted by the Editor.

‡ The white limestone when thus indurated becomes, as is well known, phosphorescent. I have found limestone, accompanying the undoubted lavas of Andernach in the Palatinate, and containing garnets and augite, not to possess this property.

In general there is no foreign matter between the substance of the dyke and the rock it divides, excepting a slight rusty appearance on the surface of the latter. The contact between the two is pretty close, but they may always be disjoined by the blow of a hammer. When the dyke is prismatic, a hollow interval between the two may sometimes be observed.

Since the average direction of the dykes is from south-east to north-west, and since the average dip of the strata in the north of Ireland is to the south-east, it will follow (independently of the several observations on the bearings of the strata contained in the table) that the direction of the dykes is nearly perpendicular to that of the strata.

Moreover since the longitudinal vallies and the metallic veins of a district are generally parallel to one another, and to the direction of the strata which they intersect, it will follow that the dykes will cross the longitudinal vallies, and that where metalliferous veins and dykes occur together, that one of the two will cut the other. This is the case at the lead mine of Kildrim in Donegal, where the dyke divides the vein. Similar facts are recounted in the Philosophical Transactions, 1790, page 93, by Mr. Mills,* as occurring at the lead mines of Persabus and Glasgow-beg in the isle of Ilay; where although the directions of the dykes are not uniform, as in the north of Ireland, yet they cut the veins nearly at right angles.

* M. Brongniart as well as Dr. Richardson from whom he quotes, (Irish Trans. Vol. 9, page 22,) appears to have misunderstood this passage, and adduces it to prove that dykes are traversed by lead veins, the reverse being the case: Traité de Mineralogie, tom. 1. p. 462. He also quotes some observations said to be made by M. Humboldt on the basalt of Unkeln, from Journal des Mines, No. 19, p. 378, to prove that dykes are sometimes metalliferous; but it does not appear on referring to that number that dykes are there spoken of, nor indeed does the reporter appear to have been satisfied with the expression "raies metalliques," or to have relied much on the accuracy of the observations.

It is very evident from these observations that some of the dykes at least were formed at a later period than the metallic veins; an inference that might be extended to all, could we show them to be all cotemporaneous. That they are so is rendered probable by their parallelism, and by the nearly uniform texture of the trap, in whatever rock the dyke is found. The simple minerals too contained in the trap favour this opinion. Calcareous and heavy spar, and lime intimately mixed with the trap abound most in the dykes of secondary rocks; iron pyrites is common to those both of primitive and secondary districts; and radiated zeolite, olivine and augite are common to the dykes of primitive rocks and to the beds of trap of secondary formation.

From this inference, however, I must except a class of dykes which run parallel to the metallic veins, and are probably intersected by that class of dykes which I have been describing in the present paper. An example of this new class of dykes is found at Farland point in the county of Donegal, where alternating strata of slaty quartz and sienite are traversed by a dyke of clay porphyry bearing east of north 21°: a dyke of trap is found at the same place bearing west of north 49°, the angle between the two being 100°. There can be no doubt that they meet one another, but the spot being covered by the sea, I could not discover the point of intersection.

Whatever date and whatever agents we are disposed to assign to the origin of dykes, their uniformly vertical and nearly parallel positions evince that both they and the mountains which they intersect have not undergone any modern disturbance beyond superficial abrasion, but that they remain in the same situation as at the remote period at which they were formed.

APPENDIX.

On the Dykes of Monte Somma, in Italy,

Extracted from a Series of Letters addressed to the late

LORD CHARLEMONT, P.R.I.A.

By the late Rev. GEORGE GRAYDON, Fellow of Trinity College Dublin.

Dated Naples.

"THE appearance of the face of the cliff of Monte Somma in its whole length perfectly coincides with the idea given by its semicircular shape, surrounding Vesuvius, as well as by its sloping back as seen from Naples, and strongly confirms the opinion of its having once formed a much higher conical hill."

"The face of the cliff viewed on a horizontal line is by no means smooth, but considerably indented in some places into semicircular or more than semicircular hollows or recesses, with sides nearly perpendicular; in others into hollows with steep sloping sides down which the sand and stones are continually sliding."

"It is formed of a great number of successive strata of lavas, in some places perhaps upwards of thirty; these strata in general are thin, that is, not exceeding from three to six feet in depth of solid stone, the intervals between them, which are generally much thicker than the strata themselves, consist of porous red or calcined and usually

* This gentleman presented a series of volcanic specimens, collected by himself on Vesuvius, to the Royal Irish Academy; vide Kirwan's Mineralogy, ed. 1794, vol. 1. preface, page xv, where he is much commended.

loose roundish stones, properly scoriæ, superincumbent on the respective strata of lava, and belonging to each; but I did not observe any stratum of vegetable mould, properly so called, though I believe there may be some puzzolana and rapilli."

"The strata are intersected in many places by walls generally perpendicular to the face of the bank as well as to the direction of the strata, in others inclined somewhat to the latter, and in some to both, and often small ones branching off from the greater perpendicular ones, and inclined to them low down in the substance of the hill itself. These seem evidently to have been fissures or cracks of the whole crust of the hill from top to bottom, into which the lava had flowed and filled them. The lava of which these are composed differs also in the same manner as that of the strata: in some it is compact and almost homogeneous, in which case the joints into which it is divided generally lie across its direction, that is, are nearly horizontal; and it is divided into irregular polygonal parts, in some places assuming a very rude sketch of basaltic columnization; in others it is porous and heterogeneous, particularly in such as are formed of the granitical lava, have a red scorified appearance and an irregularly globular structure.

"The remarkable analogy between the several circumstances of the face of Somma and of the cliffs of the county of Antrim in Ireland from Bengore head to the river Bush, must strike any one that has seen both. The principal differences between the two are, the constant uniformity of the Antrim strata, the homogeneity of their matter, their basaltic form, and the much greater depth of the strata, which are seldom less than twenty-five or thirty feet, and the less rapid inclination inwards of the strata, which there seems not to exceed an angle of fifteen or twenty degrees, whereas here in Somma the angle is not less than from forty to forty-five degrees,

which in both amounts nearly to the angle of the dip of the outward surface of the hill which they compose."

"These differences seem to have resulted from the greater vicinity of the cliffs at Somma to the seat of the crater as well as to the more rapid slope of the hill, which from the greater degree of fluidity of the lavas, and their more rapid tendency to descend, did not allow them to acquire there any considerable thickness; whereas in Antrim the distance being probably greater from the crater, and the slope much less, the lavas could settle there in greater depth. The basaltic walls also found along the coast of Antrim, and particularly of Ballycastle and Belfast, seem to have a perfect analogy with those of Somma, but are of much greater breadth in general, and the intervening strata of porous and irregular basaltic matter between them correspond exactly with those of scoriæ in all lavas, and so visible in the ancient ones of Somma."

"In the side of one of these walls of Somma, I found a crust of completely vitrified matter, covering a schistose cracked and very fragile homogeneous lava, disposed, contrary to the general rule of that kind, in perpendicular joints, and much resembling a kind of schistose hornstone, as well as the upper and superficial covering of Pleaskin."

"The whole of the valley between Somma and Vesuvius is covered with repeated irruptions of lava, particularly those of 1767, 1779, and 1787, which have run to the foot of the rock and to a considerable depth."

This description will be found to agree pretty well with that of M. Breislack (Voyages dans la Campanie. tom. 1. p. 133. Paris 1801.); from both of which it is sufficiently clear, that the walls of Monte Somma are of the same nature with the dykes of the north of Ireland.

V. *Some Remarks upon the Structure of Barbadoes, as connected with Specimens of its Rocks.*

By Joseph Skey, M.D. Physician to the Forces.

Read June 19th, 1812.

It is not my intention to offer to the Society a mineralogical description of those West Indian islands from which I have brought specimens; for, independently of the peculiar difficulties attending close and accurate researches of this nature in such a climate, my knowledge of the subject is too limited, and I am too little conversant with such descriptions to venture upon any but what the specimens themselves would seem to call for, in order to explain the circumstances under which they were collected. As however my friend Mr. Aikin has requested me to copy the few and imperfect notes which I have taken upon the subject, I beg leave to present them to the Society, together with the specimens, trusting that they will be considered as little else than their accompanying catalogue.

I would beg permission to state that Barbadoes, which furnished the specimens under notice, is an island totally unlike those immediately near it, both in appearance and in structure, as will be evident, when I lay before the Society specimens of the rocks of St. Vincent and St. Lucie in my possession.

The land is seen to rise in a gentle swell from the coast towards the middle of the island, excepting in a small district hereafter to be noticed; its highest hills have no great elevation, probably not exceeding eight or nine hundred feet, and their general direction is I think nearly north-west and south-east: its shores have no bold promontories nor rocky headlands, excepting in some few spots upon the windward, or north-eastern coast, which indeed is of a bolder character, as is the case with all the islands in these seas of which I have knowledge; perhaps too the shore is more abrupt at the opposite extremity of the island, the line of hills, which may be said in a general way to pass through the middle of the island, terminating here also in rocks of moderate height.

I understand that Barbadoes is similar in appearance and in structure to a few of the other islands in this Archipelago; to wit, that half of Guadaloupe which is called Grande-Terre, and which indeed forms a separate island from Basse-Terre, the two divisions having a channel, occasionally, if not always, filled. Marigalante, Antigua, and Santa Cruz also have a common structure with Barbadoes; they all agree in being of moderate elevation, have no volcanic traces, and are all formed of limestone rock; of this however I have no personal knowledge. Barbadoes is in great part composed of fossil madrepores, and traces of organic structure are to be met with in almost every part of the island. These remains are particularly discoverable along the whole of the south and south-west or leeward coast, and here I think the rocks assume a form which, although it obtains more or less in every part of the island, is here most discernible. The land, which when seen from the sea appears to rise uniformly from the coast, is observed on a nearer view to consist of sucessive terraces rising in two or three gradations one above the other; each terrace forming a plain of a quarter or half a

mile in breadth, and terminated by a cliff of coral rock, varying in elevation from twelve to more than twenty feet; sometimes indeed having a considerably greater height. Although these terraces are in general bounded by cliffs which run parallel to the line of the coast, yet they are not wholly uninterrupted, for here and there the high grounds advance towards the shore, and break their continuity for a short space, where the terraced form of the land is again taken up.

The rocky boundaries to each terrace are formed by broken pieces of madrepores of different species thrown about in great confusion, held together by a calcareous cement of greater or less hardness. Such are the madrepore with contiguous round cells, No. 1. and the meandritical madrepore bored by mytili, No. 2.

Near the garrison of St. Ann's, and to the eastward of it, the rocks bear the character of a dull compact chalky-looking limestone, with ramose Alcyonia, No. 3, while considerably to the westward, as in the parish of St. Peter's, the rock is more distinctly coralloidal: it contains also some natural caverns, from which very perfect organic remains may de procured.

In sinking a well at the Naval Hospital, a little to the north-east of St. Ann's, the following specimens were met with in the order in which they are enumerated, exhibiting in a striking manner the increasing compactness of the rock, in proportion to the pressure of the incumbent mass.

1. A madrepore with contiguous round cells.

2. A madrepore with detached round cells.

3. A hard porous mass with terebratulites and lenticular concretions, which are perhaps organic remains.

4. A limestone analogous to the preceding but much harder.

In no part of this district, including almost all the leeward or

south and south-west side of the island, did I ever detect any other rock than limestone, excepting that at very low water a bed of calcareous sandstone is to be seen. This rock is observed to dip to the south-west at an angle of about 25° or 30°. There is no coral rock incumbent upon it, but a small section of the broken strata is here and there observable. Such appearances are to be met with about a mile to the east of St. Ann's, and again to the westward of Bridgtown, near to Black Rock.

Towards the interior of the island this terraced appearance becomes less observable, and here too the limestone rock loses somewhat of its traces of organic structure, and occasionally even passes into a calcareous tufa.

In the windward parish of St. Philip, where also there is less of this terraced appearance, and where, if I mistake not, the hills commence which form the middle or main ridge, the rock assumes the external appearance of hard chalk; it is used for building, but effloresces on exposure to the atmosphere.

The island is almost destitute of running streams, excepting in a district which I shall hereafter notice. Upon the leeward coast I do not know of any constant stream; this no doubt is partly owing to the porous nature of the rocks, and partly to the numerous caves which are every where to be met with. These caves are sometimes of large dimensions, and in the parish of St. Thomas is one (usually shewn to strangers) which forms the bed of a subterranean stream, the source and termination of which are wholly unknown. As in all caves of this description, large stalactitic masses of fantastic forms depend from the roof.

I ought to notice another peculiarity in the features of this island which is particularly observable among the hills which slope from the central parts towards the leeward coast. The country is

here intersected by deep fissures, called gullies, which have rent asunder the cliffs, and are continued across the terraces in irregular lines.

These rents in the rocks are sometimes of great depth but of little breadth, and, generally speaking, are very precipitous in their sides, so as to be quite impassable, excepting here and there. Their perpendicular sides exhibit the structure of the coralloidal rocks to a considerable depth. Their bottoms are the beds of rapid torrents in the rainy season, and almost the only places where any native wood is now to be met with.

This scantiness of wood, together with the little elevation of the island in any part, renders Barbadoes very liable to drought, much more so than any of its neighbouring islands, and the inhabitants already speculate upon the necessity of replanting with a view to increase the fall of rain; but they will not find it an easy matter to effect a growth of wood upon their arid rocks. Even in the island of St. Vincent, where the quantity of rain is so much greater, failure perpetually follows the attempt; probably because we are ignorant of the successive means that have been required to produce the luxuriant vegetation which, under natural operations, springs from rocks almost bare of mould; and because too, we attempt to produce in a few years effects which have required ages to accomplish.

Upon the northern and north-eastern side of the island is a district several miles in length, varying in breadth from half a mile to two or three miles, which differs wholly from the rest of the island in its general features. It is in fact a mountainous country in miniature, and indeed that part of it which has most of this character is called Scotland.

I never had an opportunity of exploring it minutely, but, as far as I could judge, the rocks are almost wholly calcareous, though

less marked by organic remains than in the other districts. Sp. No. 15, which, from its texture and the pearly lustre of its recent fracture appears to be composed of shells and other organic remains extremely comminuted, is from St. Joseph's parish, which, although not strictly a part of Scotland, has features in common with it. Imbedded in this rock I found coarse flint, and a fine grained ferruginous sandstone is in contact with it: this latter is in nearly vertical strata, and is the only specimen of siliceous sandstone which I have met with in the island. The rocks near the spot are frequently found impregnated with bitumen.

The following peculiarities are observable in the district; the country is much more broken into hill and valley than any other part of the island, it has few or no gullies, is watered by some scanty streams, and has no traces of those successive stages which give so peculiar a character to the opposite side of the island. Its land boundary is in some places a very lofty cliff, and in every part a ridge of pretty considerable elevation, having a precipitous descent towards the north.

In the parish of St. Andrew this descent is the site of a spring upon whose surface floats the bitumen which is to be met with more or less in every part of the district, and is seen to exude through the soil: near some small hollows which have been made to collect this substance is a spring through whose muddy bottom carbonated hydrogen bubbles and burns with a lambent flame when a lighted taper is held above it.

The soil here appeared to be more argillaceous than that of the rest of the island, and indeed there is a pottery of coarse ware in Scotland, which I believe is the only part which furnishes the material for it.*

* The nature of the soil in this district affects its productions, which are more those of the mountainous islands than is the case generally in Barbadoes: the plantain flourishes here and here only.

Additional Note by Mr. PARKINSON.

The specimens Nos. 1. and 4. illustrate the nature of some fossil corals, showing that the forms in which they at present exist are not those which belonged to the same substances in their original state, and consequently ought not to affect their specific or generic distinctions.

In some of these specimens only circular or polygonal cavities occur, which possess no internal radiated structure, but have their insides more or less crenulated. Dr. Skey's specimen No. 4, is chiefly composed of empty cylindrical cavities with slightly crenulated sides; but in two of these cavities, near the center of the specimen, erect lamellæ are disposed in a stellular form, evincing that the corresponding lamellæ of the other cavities have been removed by accident.

In other specimens are erect radiating lamellæ not surrounded by any parietes. Dr. Skey's specimen No. 1. is also thus composed of lamellæ forming stellular columns, between which no parietes are disposed. But in one part of this specimen the compleat form of the madrepore appears, two or three of the radiated columns being here surrounded by similar parietes with those which are seen without any columnar portion in specimen No. 4, showing that this was the original form of the madrepore, and proving the identity of the madreporean remains in both Dr. Skey's specimens, Nos. 1. and 4.

VI. *Outlines of the Geology of Cambridgeshire.*

By the Rev. J. Hailstone, F.R. & L.S. Woodwardian Professor in the University of Cambridge.

Read November 18th, 1814.

THE upland parts of Cambridgeshire consist of chalk hills, being part of that great range which traverses the island in a south-easterly direction, from Dorsetshire to the Yorkshire coast. At their northern extremity they appear to rest upon an extensive bed of blue clay, provincially called *gault.* They are composed of both the varieties of chalk; of the upper containing the common black flint in abundance; and the lower or grey chalk, which contains little or none. If a line be drawn from Royston by Balsham to Newmarket, it will pretty exactly define the limits of both the varieties; the hills to the eastward being composed of the upper beds, while those to the west consist of the lower or grey chalk. Further to the east, on the borders of Suffolk and also of Essex, the chalk disappears under a thick bed of clay, which occasions a corresponding difference in the soil and its produce. To the west, a succession of hills composed of beds of grey chalk with wide intervening vallies of gault occur; till on the extremity of the county, at Gamlingay and Potton, a tract of sand comes in, evidently connecting the strata of Cambridgeshire with those of Bedfordshire. And here the features of the former county undergo

a manifest alteration, its high elevations subsiding by degrees into the sand hills of the latter.

Upon some of the highest hills near Cambridge, a deposit of gravel and loose stones in horizontal layers, has lately been found, resting immediately upon the chalk. This gravel differs in so many respects from the red ferruginous gravel found dispersed in patches over the gault in the subjacent flat, that I think it must be considered as a deposit of a different epoch. It contains numerous fragments of strata belonging to the oolite series, which occur in the neighbouring counties of Northampton and Rutland, surrounding Cambridge on the west and north-west. Pieces of basaltic rocks are sometimes found, but these are not very common. These fragments are of all sizes, and worn down in different degrees. Some are pebbles intirely rounded; others have their edges merely blunted. Some appear so tender and so little capable of resistance, that it is difficult to conceive how they have been transported without being entirely destroyed. The prevailing material of these masses of gravel, is the pale blue or light grey variety of flint, with numerous traces of the alcyonium or other similar bodies in its substance.

According to my observation, this variety of chalk flint is not so common in the southern parts of this great chain, whilst in its continuation through Lincolnshire and Yorkshire, scarce any other is to be met with. The two principal deposits of the gravel of which I have been speaking are to be seen on the summit of Gogmagog hills, and on Harston hill about five miles to the south of the former. The height of these hills may be estimated at 800 feet above the river at Cambridge.

Harston hill has been examined by Mr. Warburton, Secretary of the Geological Society, who has obligingly communicated the

result of his observations to me. Mine were principally made at the pit on Gogmagog hills; and as the contents of the two pits seem to differ in some respects, I have great pleasure in subjoining his remarks in the same terms as they were conveyed to me. His conjectures as to the cause of these alluvial deposits, will be read with great interest by Geologists.

"The hill at Harston is of a conical form, and situated about a quarter of a mile S. E. of the village, and about five miles S. W. of Cambridge. I selected from the rubble which is deposited on the summit of the hill the following specimens.

1. Rounded pebbles of very hard chalk, scarcely softer than the Antrim limestone. These compose three-fourths of the mass of the rubble.
2. Angular masses of striped flint. These are numerous and very large; one cylindrical piece that I measured being one-third of a foot in diameter and one foot long.
3. Fragments of septaria.
4. Fragments of a shelly limestone.
5. Ochreous balls, resulting probably from the decomposition of pyritous nodules.
6. Angular or scarcely rounded pebbles of trap or greenstone.
7. Organic remains, viz.

   a small fusiform belemnite;
   a large belemnite;
   a small gryphite;
   a large oyster; vide fig. 7 & 8. Pl. 8. Townshend;
   some bones and teeth.

The appearance of these specimens is not very inviting; but they are not without interest.

The pebbles of hard chalk are probably the remnants of the bed which immediately covers the green sand and the gault, of which these are either fragments rounded by attrition, or they are the nodules peculiar to the lower chalk, (as may be seen in Wiltshire,) washed out of the bed itself, which is disintegrated.

No. 2 is *probably* a variety of common flint; specimens of this substance are not uncommon, in which there is an appearance, as in a Scotch pebble, of alternate layers of deposition. The action of air and moisture might render these natural divisions more visible, just as slates are obtained by the exposure of the blocks of fissile stone to the weather.

As other beds, besides the London clay, contain septaria, we cannot say from what bed the fragments of this substance are derived; nor will any of the specimens previous to No. 6, furnish any data for guessing the nature and direction of the current, which has heaped together this mass of confusion.

The mass of greenstone nearest to Cambridge is found in the toadstone beds of Derbyshire, to some specimens of which the pebble No. 6, bears a close resemblance. Few of these pebbles weigh less than 8 ounces.

The large oyster is the same with fig. 7 and 8 of Pl. 8 of Townshend's work, and belongs to the bed which underlies the coral rag.

The large belemnite is peculiar, I believe, to the lower oolite.

The bassetings of the three last mentioned beds, that is, of the toadstone, the coral rag and the lower oolite, are found (at least in England) only in a direction west of Cambridge; so that we are led to explain the accumulation of these alluvia by the agency of a powerful current flowing from west to east.

The rubble rests on the summit of a conical hillock, the sides of which consist of naked grey chalk; than which one can hardly suppose a situation more unfavourable for the accumulation of alluvial matter; at any rate why is not this found in as great abundance on the flanks as on the summit of the hillock? This looks like the partial destruction of an alluvial level by some subsequent cause, the discovery of which I leave to more learned members of the Society."

Thus far Mr. Warburton. With respect to the hard chalk pebbles it may be proper to remark, that in some parts of the chalk formation a harder bed is found, of a close grain and compact texture, which might very well supply the material from which these pebbles have been formed. This bed may be seen at Sudbury in Suffolk, and I have also observed it in some parts of the Yorkshire wolds. The striped variety of flint is also to be met with in the ordinary chalk of the same hills. I have before observed that a distinction must be made betwixt this deposit and the ordinary gravel found at a lower level; and in fact throughout the Isle of Ely such a distinction is universally admitted, the one being called the *white* gravel and the other the *red*. The same distinction is known in Dorsetshire, as I learn from De Luc's Travels, vol. ii. p. 77, in a passage particularly illustrative of these two deposits.

It would be unnecessary to trouble the Society with any observations on the chalk bed with flints, as I am not aware that they present any thing new, and their phenomena may be studied in other parts of the island to greater advantage. I pass therefore to the lower beds or grey chalk, which composes by far the greatest part of the hills of Cambridgeshire. These beds, as is well known, contain no flints, but, not uncommonly, dispersed masses of the

radiated pyrites, globular or kidney-form. It is considerably harder than the common chalk and its colour is usually some shade of grey. It is well known in this county under the name of *clunch*, and is the material from which the best lime is burnt. Some of the beds are hard enough to serve the purpose of building stone, and are quarried and shaped in blocks for that purpose. It also endures the fire well, and, like the Ryegate stone in London, is much esteemed for the backs of grates and other similar applications.

This stone is dug in the greatest quantities at Reach, a small hamlet in the parish of Burwell, situated on the skirts of the fen country precisely where the Devil's ditch terminates in that direction. The excavations at this place are immense.

Clunch, when burnt, affords a lime in such universal esteem that the crude material is sent from hence for that purpose as far as Peterborough and other distant places, within reach of the water carriage of that level district.

The bedding of a chalk hill is difficult to ascertain, on account of the great number and irregularity of the rifts and joints intersecting the stone in all directions. By careful observations however, made in different places, I am enabled to state that the general direction of the beds is from the N. E. to the S. W. and that they have a gentle inclination to the S. E. Their direction consequently coincides with the line that I have mentioned above, as dividing the upper from the lower chalk.

In one of the pits at Reach a bed of clunch occurs, which differs from the ordinary sort and presents some remarkable appearances; the mass itself is much harder, and stuck full of concretions of a yellow indurated marl: outwardly they are of a green colour arising from the oxide of iron: they are in general kidney-shaped

and of all sizes, from a hazel nut to an ordinary potatoe. The shape of the bed also deserves notice; its general thickness is about fifteen inches, which it preserves for near thirty yards, as appears in the section of the quarry; it then diminishes at each end to a thin edge, and at length totally disappears. At a short distance in front, there happens to be left by the quarry-men an insulated butt, where this bed is not found at the level where it might be expected; the conclusion therefore is, that it has terminated also in this direction in a similar manner: thus, as to its figure, putting the practical geologist in mind of the mineral deposit called a pipe-work in the lead countries. I must however observe that in an extensive pit at Kneesworth on the other side of the county, the same bed occurs again, where it preserves an uniform thickness and direction like the other beds with which it is associated. In general, I take this to be the bed which Mr. Townsend* notices as hard and rubbly, and found in descending the hills from Everly to the vale of Pewsey. It has also been observed by Mr. Warburton at Marlborough.

I have never been able to observe any strong line of separation betwixt the clunch and the succeeding stratum of gault on which it rests. I believe they pass by degrees into each other. The lower beds of clunch become more sandy, and gradually assume the nature of an argillaceous loam. In the next observable stage of transition, the mass assumes a greenish grey colour, and a plentiful admixture of dark green sand is uniformly dispersed through its substance. At the same time it contains numerous irregular dark brown nodules of a ferruginous indurated marl. At length these foreign matters disappear, the mass becomes uniform and ends in the bluish clay or argillaceous marle called

* A Character of Moses, vol. 1, page 98.

gault. This occurrence of green sand in the confines of the two beds was first noticed by Mr. Warburton at the brick pits near the Castle hill, from which he inferred that it always takes place under the same circumstances: an inference which is borne out by the testimony of the most experienced brickmakers about Cambridge.

I am at a loss where to class the bed of sand and sandstone which lies over the gault at Ely, and forms in some measure the elevation on which that city stands. It contains particles of green sand, but not in sufficient quantity to be characteristic. It is principally a concrete of siliceous sand, with small rounded fragments of ironstone and quartz pebbles: the bed is from eight to twelve feet in thickness, and perhaps an alluvial deposit.

It is unnecessary to trouble the Society with an enumeration of all the organic remains that are to be found in the clunch or chalk beds, they are in general the same as occur in other parts of the kingdom where the chalk formation presents itself. Of the remains of fish we find their teeth, bony palates, and in many cases their brown scales not much altered. Cornua ammonis occur and some bivalves apparently of the chama and mytilus genera. Of the former genus I have found the haliotidea very distinct. The anomia terebratula occurs in the beds at Reach. In the vegetable kingdom the fruit cones of Cherry Hinton deserve a particular notice. As early as Woodward's time this fossil had attracted the attention of naturalists, and two very perfect specimens in his collection appear to put their vegetable origin beyond doubt. In confirmation of this opinion, I beg to refer to a fossil in the collection which I have the honor to transmit, which I met with at the same pit, and seems to be the impression of a branch of some vegetable of the fir tribe, with the linear leaves surrounding it.

VII. *Some Observations on a Bed of Trap occurring in the Colliery of Birch Hill, near Walsall, in Staffordshire.*

By Arthur Aikin, Esq. Secretary to the Geological Society.

Read November 20th, 1812.

ALTHOUGH several instances have come under my personal notice in Shropshire and the adjacent counties, of the occurrence of trap rock in connection with the coal-formation, yet in all these cases the trap either forms the basis on which the coal strata rest, or is incumbent on them; or, in the form of dykes, fills up the fractures or faults. Being informed however by Mr. James (one of the members of our Society) that a bed of trap had been pierced through in several places in a colliery, at Birch-hill near Walsall in Staffordshire, which has lately come into his possession, I took an opportunity of visiting the spot in the course of the last summer, and beg leave to lay before the Society the result of my examination.

On my arrival I found that the lower part of the works (in which the bed of trap is situated) was not as yet sufficiently freed from water to admit of actual inspection; but being furnished with

a plan of the colliery and with registers of the strata pierced through in sinking the three deepest pits, having also an opportunity of questioning several intelligent miners who had themselves worked in the colliery, and of examining many tons of trap rock and of the adjacent beds which had been brought to the surface, I think that there will be found no material error in the following statement.

The surface of the colliery at Birch-hill (Pl. 12. fig. 1.) somewhat exceeds 83 acres; and is itself only part of a more extensive coal-field, the portions of which adjacent to the present colliery have been worked out so long ago as to preclude the obtaining any correct information concerning them. The ground rises with a very gentle slope on the east, falling nearly flat and becoming marshy on the west. On the south-western edge of the colliery is a low ridge, from 20 to 30 feet above the level of the marshy land at its foot, from 70 to 100 yards broad, and extending along the southern edge of the colliery for 3 or 4 hundred yards, till by degrees it coalesces with the general slope of the land, and is no longer distinguishable. This ridge is named the *green rock* fault, and forms the separation between the Birch hill colliery and an exhausted one adjacent to it on the south.

There have been about twenty pits sunk at different times, more than half of which are in the south-western angle of the colliery; not one of these has reached the bottom of the coal-formation, and therefore the rock upon which it rests is unknown: I apprehend however (from the general analogy of this part of the country) that the fundamental rock is flœtz-limestone.

The following is a list of the strata in pit B, from the surface to the greatest depth that has been hitherto attained, viz. 216 feet.

		Ft.	In.		
1.	Soil and gravel	4	0		
2.	Blue and grey clunch with balls and measures of ironstone	12	6		
3.	Coal (not worked)	2	0		
4.	Clunch mixed with ironstone, and including a bed of the same 15 inches thick	35	6		
				54	0
	The open-work, and the six pits called by the miners *Stone-pits* (marked *a*,*a* in the plan) are for the purpose of procuring the ironstone contained in the beds already mentioned, and therefore on an average do not exceed the depth of 54 feet.				
5.	Coal (not worked)	0	10		
6.	Fire clay	5	0		
7.	Rock binds (slaty clayey sandstone)	27	2		
8.	First coal or Yard coal	2	2		
				89	2
	The Yard coal is the first coal which has been worked; it is soft, and applicable only to domestic purposes or to the roasting of the ironstone: its thickness varies from 26 inches to a yard. The three pits marked *d* in the plan are sunk into this bed: their average depth does not exceed 90 feet.				
9.	Sandstone, the upper part of the bed slaty, the lower compact	38	4		
10.	Strong coal	4	1		
	This is the second workable coal; it is of good quality and is coaked for the use of the furnace.				
11.	Alternations of compact sandstone, slaty sandstone, slaty clay, and clay	28	2		
12.	Coal and bituminous slate (not worked)	1	6		
13.	Brown clay	11	0		
14.	Sandstone and indurated clay	5	6		
15.	Black slaty clay inclosing three beds of ironstone of 9, 3, and 5½ inches in thickness	10	10		
16.	Trap *(green rock)*	12	0		
				200	7
	The pits A & C are sunk into the trap, the one to the depth of half a yard, the other to the depth of five yards, but neither of them passes through this bed.				
17.	Indurated sandstone	3	0		
18.	Carbonaceous slaty clay and blind coal	4	4		
19.	Slaty clay	1	6		
20.	Strong hard bituminous coal	4	5		
	The above two beds of coal, with the thin interposed bed of slaty clay, form the third coal which is worked.				
21.	Fire clay	2	0		
				215	11
	The Engine pit, the Bye pit, and the pit marked B, terminate in this bed.				

Besides the green-rock fault, already mentioned, there is another which passes through the colliery longitudinally in a direction E. by S. and W. by N. This fault is a mere dislocation of the strata causing a depression of 72 feet to the S.: a smaller fault or *Rider* branches off nearly due W. from the larger one causing a further depression of 4 feet in the strata which lie immediately to the S. of it. The junction of these two faults takes place precisely under the Furnace.

The beds on each side of the central fault rise nearly S. at an angle of about 6°; but, in the immediate vicinity of the green-rock fault, the second coal and all the beds lying above it (as far as they have been explored) are thrown up at an angle so rapidly increasing as, in the space of about 100 yards, to amount to 25°.

None of the beds are known to vary materially in thickness except the trap. The thickness of this latter in the Engine pit and in the Bye pit amounts to 24 feet, but in the pit B it is diminished to 12 feet, and in the pit D which is sunk down to the third coal the trap is wholly wanting. The miners themselves conclude from these facts, and apparently with reason, that the bed of trap is merely a great wedge from the green-rock fault which has intruded itself between the proper coal strata, but is by no means co-extensive with them.

To the geologist the circumstances connected with the relative situation of the trap and with the state of the beds that lie immediately above and below it are of singular interest; and it happens fortunately that the two most interesting of these beds, namely the indurated sandstone and the blind coal, have been explored to the distance of several yards. This was effected in driving a heading for ventilation from pit A to the pit B, see section Pl. 12, fig. 2.: this heading was begun in the first or yard coal, but on passing the

great fault (which was then first discovered) the miners found themselves unexpectedly in the upper bed of the third coal (i.e. the blind coal), and in this they continued to drive forwards the heading to pit B, a distance of about 100 yards.

I now proceed to a more particular description of the trap and of the adjacent beds.

The colour of the trap is a dark bluish green; it has a glimmering lustre from the intermixture of minute, shining, crystalline laminæ; its fracture is uneven, and it breaks into irregular wedge-shaped blunt edged fragments; it is tough, acquiring a kind of polish under the hammer, moderately hard and rather heavy. It attracts very strongly the magnetic needle, but does not exhibit any signs of polarity: it effervesces moderately on being immersed in cold dilute muriatic acid, and on examination with a lens appears to consist of felspar, of calcareous spar, of minute shining black grains, and of a brownish, blackish, and bluish green substance, which I suppose would generally be considered as amorphous hornblende: it is to be remarked however of this latter substance that it exhibits no appearance of crystalline laminæ, and that if a piece of the entire rock be digested in boiling dilute nitro-muriatic acid this green matter is almost entirely dissolved with considerable effervescence; and the stone assumes a greyish white colour consisting almost wholly of crystalline laminæ of felspar.

This trap or greenstone is penetrated by contemporaneous nearly vertical veins of calcareous spar, from the size of a mere thread to about half an inch in thickness. The rock, although very compact in its recent state, after a few weeks exposure to the air, acquires a liver-brown colour and crumbles to pieces.

The slaty clay, with subordinate beds of ironstone, which lies above the greenstone, differs but little from the common slaty clay

of the coal formation. This however is by no means the case with the three beds that lie immediately below the greenstone, namely, the indurated sandstone, the carbonaceous slaty clay, and the blind coal.

The indurated sandstone is of a yellowish grey colour, dense, compact and ponderous; it consists essentially of fine grains of quartzy sand and silvery mica, and contains very slender imperfect veins of calcareous spar, and small irregular granular concretions of ferriferous carbonate of lime: these concretions decompose by exposure to the air, and give the external surface of the stone a brownish yellow ochry tinge. In the specimens that have come under my notice, the surface of the greenstone where it is in contact with the sandstone, is of a brown colour, and decomposed to the depth of an inch or more; but I have not observed any direct mutual penetration of the two beds. The lower part of the sandstone, however, is considerably broken, and angular pieces of the carbonaceous slaty clay (technically called *batt*) occur, completely involved in the sandstone.

The characters of the batt, if taken from that part of the bed where it is not covered by the greenstone, are those of common bituminous shale or soft slaty clay, inclosing seams of pitch coal about one-fifth of an inch in thickness: but wherever this bed is covered by the greenstone, the slaty clay is considerably indurated, the coal is also harder and more compact, and possesses a brilliant semi-metallic lustre; and both the clay and the coal are wholly destitute of bitumen.

Below the batt lies a coal four feet thick, which, where covered by the greenstone, has a shining somewhat iridescent lustre; it is entirely destitute of bitumen, and when put in the fire burns rapidly, like common cinder, differing materially in this respect

from the Culm of South Wales, or the blind coal of Kilkenny; but where this coal is not covered by the greenstone, it exhibits the usual characters of common bituminous stone coal.

The beds below this coal differ in no material respect from similar beds in other collieries.

Hence it appears that the Birch-hill colliery presents the following important facts: First, the existence of a bed of greenstone interposed between the usual strata of the coal formation, but not co-extensive with them; and secondly, that the coal and bituminous shale, where they are covered by the greenstone but protected from actual contact with it by an indurated sandstone a yard in thickness, differ materially in many respects, but chiefly in being deprived of bitumen, from those parts of the same beds where they are not covered by the greenstone. The works have not indeed been sufficiently opened to demonstrate that the changes just mentioned are strictly co-extensive with the greenstone, yet I think we may infer by fair analogy that such is the case; and that the greenstone is necessarily concerned in bringing about these changes.

Professor Jameson, in his mineralogical account of Dumfriesshire, mentions beds of greenstone occurring in the independent coal formation; and I at first took for granted, that the greenstone above described was also a true bed. On further consideration, however, I am rather inclined to adopt a contrary opinion, for the following reasons:

In the first place the green rock fault being composed of precisely the same kind of greenstone as the bed is, renders it probable that the one is a continuation of the other; and this is still further confirmed by the gradual thinning out of this bed as it recedes from the fault; for in the pit B, the most distant one that has been as yet sunk through the greenstone, this bed is 12 feet thick, while in

the engine and bye pits, which are the nearest to the fault, the same bed is 27 feet thick. The actual junction of the greenstone of the bed with that of the fault has not indeed been proved, but from the very little unexplored space at present between them, there can exist but little doubt I imagine as to the fact. Now, though it is possible that the outburst of the greenstone (supposing it to be really a bed) may so coincide with the elevation and curvature of the ridge as, with a thickness of no more than about 30 feet, to give the appearance of a rock 60 or 100 yards across, yet this hypothesis is scarcely consistent with the rapid increase of the angle at which the strata above the greenstone bed are elevated in the vicinity of the green rock fault, advancing in a few yards from 6° to 25°. The absence of the greenstone bed in the pit D. though it is full as near the line of bearing of the fault as the engine and bye pits are, is a further support of the opinion that I have hazarded. Upon the whole, then, I am inclined to consider the green rock fault as a fissure in the coal field, filled up by greenstone, and the supposed greenstone bed as a wedge-shaped prolongation of the same.

With regard to the mode in which this and similar fissures have been filled, whether by deposition of the constituents of greenstone from solution or suspension in a superincumbent aqueous fluid, or by the bursting from below upwards of earthy matter, either melted or in the state of boiling hot mud, like the mud-volcanoes of Mexico and of the island of Taman in the sea of Asof, I shall not pretend to decide.

VIII. *A Geological Description of Glen Tilt.*

By John Mac Culloch, M.D. F.L.S. President of the Geological Society, Chemist to the Ordnance, and Lecturer on Chemistry at the Royal Military Academy at Woolwich.

Read Dec. 3, 1813, and the Supplementary Additions Dec. 16, 1815.

It is well known that the appearance of the granite in various parts of the valley of the Tilt afforded to Dr. Hutton one of the original arguments on which his theory was founded. Hence this spot has acquired among geologists a sort of classical celebrity, sufficient to render it an object of interest, independently of that which is excited by the intricate and remarkable disposition of its rocks. Observations, now more numerous than in his day, have brought to light so many facts similar to those which appeared to him so important, that there is no difficulty in pointing out abundant instances of an occurrence once supposed rare. But having had occasion while examining these rocks to observe other interesting appearances, which have been either misapprehended or overlooked, I consider that a notice of them will not be unacceptable to the Society. The notice is accompanied by such specimens and drawings as are requisite for the illustration of the subject.

In describing Glen Tilt I have been under the necessity of differing on certain points from those who have preceded me. An examination of many of these points of difference would lead to discussions as endless as they would be fruitless, and give this

paper the aspect of a controversial essay, rather than of that to which it alone pretends, a descriptive one; for which reason I have chosen to describe it precisely as it appeared to me. Where my description differs from that of others, the differences will be found to consist at times in a difference of opinion respecting the denominations of rocks, while on other occasions they are much too great to admit of their arising from a different use of the same terms, or a different mode of contemplating the same phenomena; they are differences respecting facts, and are therefore the less fit subjects of discussion.

As the local circumstances which require to be examined before an adequate notion can be formed of the true structure of this interesting place occupy a considerable range of country, and as inevitable confusion would follow any attempt to describe the mineral beds and their geological connections in their natural order, on account of their perpetual interference with the geographical disposition of the ground, I have chosen to adopt a geographical method. In so doing I shall the more readily be understood as far as the simple specification of facts goes, and those who shall incline to follow me in the investigation of this spot will also be furnished with a clue by which they may trace the description, and the more easily confirm or refute, as it may happen, that which I shall relate. In the present state of geological knowledge, this method of proceeding seems absolutely necessary. Like the detail of chemical experiments it enables the reader to follow step by step the appearances from which the general results have been deduced, to examine the inferences as they are drawn from the phenomena, and finally to determine on the legitimacy of the conclusion. Such inferences or such general conclusions, as appear to me to result from a comparison of these facts duly approximated, will be stated afterwards.

In examining such a valley as that which is the subject of the present paper, the course of the river, as well as the ranges of hills which bound it, must necessarily enter into the history of its geological formation. Where these are of similar structure it is easy to comprehend the whole in one line of description, taking the course of the river for a guide. But in Glen Tilt a dissimilarity so complete is observed between the opposite sides of the valley, and the numerous and interesting phenomena which occur in the bed of the stream itself are so dissimilar to both, that it is impossible to convey an adequate idea of the whole structure without a distinct examination of the three several lines. A perpetual transference of the imaginary spectator from one point to another, would produce as much confusion in the narration, as such a proceeding in examining the ground would obscure the judgment and puzzle the investigation of the real observer. I have therefore chosen to detail the examination of the three lines separately, and have commenced with the river as the most natural if not the most useful method, describing in succession the ranges of hills, of which the history is required to render the phenomena which are to be seen in the river intelligible.

The Tilt has its rise in a small loch not far from that long valley which is the common division of the waters running east and west to join the Dee on one hand and the Tumel on the other. As it enters that valley it falls immediately into a line tending westward, from which it deviates towards the south-west before its termination in the Garry, the narrow bottom of the glen affording but little room for lateral deviations, and its direction being subject to no material variation. For two or three miles its course lies so much through alluvial matter that it offers nothing to the spectator; nor does any material feature occur before its junction with the Tarff.

Occasionally it may be seen cutting its way through quartz rock, through schist, and, not long before its arrival at the Tarff, through beds of dark bluish limestone. One solitary portion of pure white limestone or marble is also visible in this part of its course. Where it joins the Tarff it also receives another stream of considerable magnitude, flowing from Glen More and collecting the waters from a set of vallies that lie between the foot of Carn-ree and the head of Glen Fernat, as well as from those corys of Ben Gloe which tend in this direction.

It will be unnecessary to particularize the several streams which it receives during its course to the Garry, unless where their sections offer material information respecting the structure of the neighbouring hills.

Having passed the Tarff it begins to run in a more rocky channel, and though often, and for considerable spaces, its true bed is concealed by the alluvial matter which it has accumulated, enough remains exposed to excite the curiosity, and employ no small portion of the time of a geologist. Although in enumerating and describing these several points where the natural bed is visible, I have used all my endeavours to specify the particular places where they occur, yet in this respect the description will still be deficient. Even if an accurate survey of the ground were made, the want of points of reference in a valley which possesses so few permanent marks for distances, would prevent me from referring to them as accurately as would be desired by those who might wish to follow the same track. The difficult nature of the banks, and the many inaccessible points which the river possesses, combined with the dangerous violence of its waters, frequently also deny access, and may consequently have led to omissions. Such omissions will also be found to arise from another cause, to which may equally be

referred some discrepancies and errors in the measurements of the remarkable rocks which are seen in its bed. This cause is the variable state of the water, which at times exposing more or less of these projections in its bottom, alters their apparent magnitude as well as their number. I have been rendered sensible of these differences by examining its course at different periods, but since some confusion would have resulted from any attempt to correct the first examination which I made, I have preferred giving it as it was first recorded, with the caution against implicit reliance in the measurements which I have now laid down. It is only necessary to say that the observations were made in a kind of medium height of the water, and that as the geological consequences are in no wise affected by this sort of inaccuracy, I held it unworthy of correction. The statement of the circumstance was however necessary, lest the discovery of inaccuracies of this nature might lead to doubts with regard to more important observations. The measurement given in yards is merely a rude computation from pacing, but it is fully adequate to the purposes in view; since neither the facts nor reasonings can in any way be altered by a greater or less nicety of admeasurement.

Descending therefore the course of the river from Poll Tarff, (See Map plate 13) the junction of that stream with the Tilt, a large body of granite will be seen crossing it above the Shepherd's hut, and a small granite vein may also be observed above it at a little distance. The bed of the river from Poll Tarff to this point, wherever it is visible consists of dark blue limestone alternating with quartz rock. At the distance of four or five hundred yards from the burn of Aldianachie, a large rock consisting of a complicated mixture of granite and schist crosses the Tilt again. I shall not here dwell upon the circumstances which attend this mixture, as better opportunities of describing them will occur hereafter.

It is not far below this place, but at a distance which I have neglected to note, that a great portion of a limestone bed will be found crossing the river. It is much contorted, and is also reticulated with a few granite veins. Here the alternation of the limestone with the quartz rock is also visible, and they cross the river together. The limestone is in this place uncommonly hard, and in its composition very siliceous. Its external aspect where it is worn by the action of the water, is not much unlike that of a granite or porphyry, and it has in fact been sometimes mistaken for one or other of these rocks. Continuing to descend nothing remarkable occurs till we arrive within about two miles of Forest lodge, where a rock like those last mentioned, traverses the bed of the river. This rock consists of a great mass of red granite so mixed with quartz rock and hornblende schist, that neither pen nor pencil can describe their confusion. Limestone may be observed both at its upper and lower edge, and this is traversed and reticulated by small granite veins. The whole mass occupies a space of about 150 yards. It is proper to remark here, that the blanks which occur in this account of the bed of the river are such as in general arise from its course being over a bed of alluvial matter which covers and conceals the fundamental rock, while in other cases they arise from those portions of the natural bed which are visible being trivial or unimportant, or from the state of the water which prevented its bottom from being seen.

The next, and of all perhaps the most remarkable rock to be observed in the course of the Tilt, occurs at a bridge a short distance above Forest lodge. A large mass of red granite is first seen occupying the bed of the river for a considerable space both above and below that bridge. Associated with this mass of granite are various rocks, so disposed and intermingled that neither description, nor draw-

ing, nor specimens, can give an adequate idea of their disposition and confusion. The drawings which accompany this paper may serve to illustrate a description which can only be general, since no drawing less in size than the rock itself could give an accurate representation of the place.* In contact with this great mass of granite, which for a certain space offers no very particular feature, are seen rocks of a schistose nature. These are succeeded by blue limestone, and subsequently by schist and granite, but in a state of disorder so inexplicable, that I do not attempt to describe their relative positions. No appearance of parallelism is to be seen in the schistose rock, but the limestone, although much bent and twisted, has the aspect either of a complicated vein, or of the edges of a bed in a vertical position, the portions of which have been split asunder and filled with other materials. The lamellar form of this limestone and its connections with the surrounding rocks, leave however no doubt of its being the exposed edge of a bed, and it must at the same time be remarked that besides being placed in a vertical position, the line of its course is at right angles or nearly so to the general bearing of the strata, of which it seems once to have formed a regular constituent part. Viewing the whole of this compound mass of schist and limestone as a single rock, and the granite as another, it is easily seen on the most superficial glance, from the strong contrast between the dark grey of the former and the red of the latter, that the dark rock is intersected and disturbed by innumerable veins of granite. These traverse it in every possible direction, and are of various sizes, the smallest not exceeding that of a thread, and reticulating the dark rock in a most intricate and amusing

* Vide Plates 14, 15, 16, 17, 18.

manner. Such is the ordinary view which has been taken by one class of observers of this rock, as well as of all the other rocks seen in Glen Tilt. They have been looked upon as mere masses of schist intersected by veins of granite, the larger bodies of granite being considered as veins, the origin and direction of which were unknown, and the smaller ones as ramifications proceeding from them. A different class of observers, seeing in this imagined schist nothing but its approximate position with granite, have considered it as offering an example of the alternation of these two rocks. In whatever way the different theories may be affected by these distinct views of this case, I have no inclination at present to enquire. If one of them be incorrect, the other is imperfect, and the object of this paper is rather to give a more full account of the appearances to be observed in this place, than to renew a controversy on the same grounds on which it has already been agitated.

Independently of such considerations, the disposition of the rocks at this place, as well as in other parts of the Tilt, are so curious, and as yet so solitary and new, as to render them highly attractive and well worthy of record. It will however be seen hereafter, that the history of these several appearances, even if it should not be supposed to add any strength to the general theory respecting the posteriority of granite, serves at least to give us an accurate idea of the real structure of the valley itself.

The remarkable novelty here visible, and in which the junction of the granite with the superincumbent rocks differs from all similar junctions formerly described, is that of the interference of granite and limestone. The granite veins which traverse the schist, pass equally into the limestone which accompanies it. These veins are occasionally of large size. In this case they can sometimes be traced into

the larger masses of granite with the same ease as when they traverse the schist: in others, however, they appear both to originate and end in the limestone, and present rather the aspect of detached lumps and irregular processes than of veins.* So confused is this interference, that a fragment of granite is often found entangled in the limestone, and a lump of the latter will sometimes be found intruding into the former. The minuter veins of granite are generally if not always connected with the larger pieces, and they intersect and reticulate the whole limestone as they do the schist, diminishing at length to the thickness of a leaf of paper or a thread. But there is a still more remarkable arrangement of the limestone and granite. Parallel to the limestone bed or beds, and following every flexure and contortion which it undergoes with the most perfect regularity, are to be seen narrow lines rising above the general surface, and accompanying the course of the bed through its whole extent. On examining them they are found to consist of a harder substance which has resisted the action of the water, while the softer and intermediate parts, being of limestone, have been dissolved and washed away.‡ The fracture of the rock shows that these are the edges of laminæ formed of a reddish siliceous substance precisely similar to that which constitutes the reticulations, and which from the contrast of its colour to that of the blue limestone with which it alternates, is always easily distinguished.

Having blown up a considerable portion of this rock, I am enabled to say that it is of a laminated texture throughout, being a bed of which the alternate layers are limestone and that siliceous red rock which I consider as a modification of granite. A perfect notion of such a limestone may be formed by recollecting the appearances

* Vide Plate 15. ‡ Vide Plates 15, 16, 17.

of those laminated limestones which contain alternate layers of micaceous schistus or clay slate.

There is yet one other disposition of these two classes of rock; this consists in minute points or fragments, if they may be so called, of the same siliceous matter, inhering in the limestone, and which from their smallness are scarcely to be detected, unless where from having been exposed to the action of water they are found to give a rough and echinated surface to the calcareous rock. This appearance is very widely diffused through the whole extent of the body of limestone hereafter to be described, as forming a great portion of this district, wherever it is found in the vicinity of the great mass of granite.

The singularity of these appearances renders it proper to dwell a little on them, and to enquire into their connections and probable origin. Saussure indeed has mentioned a transition from granite to limestone, and, as there are some situations in Glen Tilt where the limestone in contact with granite becomes so siliceous and indurated as by degrees entirely to lose its mineralogical, and pretty nearly its chemical character, so it is possible that he may have met with some similar fact, although no very accurate notion can be derived from his account of it and consequently no assistance obtained from his observation.

As I shall have occasion to enter fully hereafter into the mineralogical description of this and of the other rocks which occur in Glen Tilt, and shall then vindicate the term granite, which as a general term I have applied to it, I think it only necessary to say at present that the mass of rock above described as traversing the stratified rocks, is a portion of a more continuous one which may be traced to the hills constituting the right hand or northern boundary

of Glen Tilt. It is not an independent vein. So far therefore the geological connection, as well as the identity in mineralogical character of the mass of granite which is approximate to the limestone and schist with the granite mountains of the northern ridge, is indisputable. From this mass, processes or veins of different sizes are seen to issue, until they gradually terminate, as I before said, in a thread. As long as these veins continue of a few inches in breadth, their mineral character remains unaltered. As they diminish, however, the hornblende gradually disappears, although, in the cases in which the vein traverses hornblende schist, this mineral is increased in quantity, and the vein assumes rather a more decided character of that rock which, as I conceive, is inconveniently distinguished by the term syenite. But the vein of mixed quartz and felspar is the most common, and this, as it continues to diminish in size ultimately becomes mere felspar, or else a compound of felspar and quartz so intimate, that the magnifying glass discriminates the particles no longer, and the whole is only distinguishable from common felspar by its peculiar fracture and superior hardness. This circumstance, the varying composition of granite veins, is not unusual, and it may be observed, among many other places, in the Corpach bason of the Caledonian canal. Now, however inaccurate it may be in a mineralogical point of view to designate the substance which constitutes the minuter veins by the term granite, yet for the purpose of geological reasoning it is unavoidable, nay, proper, since the substances have an absolute continuity or geological identity. It would be unjust either by a misapplication of terms, or an undue nicety in their use, to reject any geological argument which might be founded on such a fact as this. The same is true of the siliceous laminæ found in the limestone,

as well as of the detached pieces and small points, since they are absolutely identical in composition with the smaller reticulations.

With respect to the limestone, it is subject to a variation of aspect where it approximates to the granite which it is interesting and important to notice. The colour of the great limestone mass is lead blue of various intensity, and its texture is almost universally large grained and highly crystalline. It is true that in some few instances it preserves this aspect in the situations described, but, in the greater number of cases, particularly in those where it is penetrated by the smaller veins and where the beds have undergone an elongation or a contortion, the crystalline texture disappears. It then assumes an appearance exactly resembling that of hornstone or compact felspar, having a smooth texture, with a thin-edged fracture intermediate between the splintery and flat conchoidal. I may as well add here that the schist is often of an argillaceous, but highly indurated, character, and also that it often passes into hornblende slate, and this (it is worthy of notice) the more frequently as it approximates nearer to the granite.

So much has been said with respect to the origin of granite veins, and on the mode by which their intrusion into the schistose rocks which generally accompany them has been effected, that it is superfluous to repeat it, since nothing new can be offered on the subject. By whatever mode it has been produced, it is obvious that the same explanation will apply to the case of the limestone which is interstratified with the schist, as far at least as the veins are concerned, although the fact itself be a new one. But how has the alternation of laminæ of granite with those of limestone been effected?

It is necessary here to anticipate that which will be fully described, and, I trust, proved hereafter in a more proper place, the

original regular position and the posterior disturbance of these stratified rocks. The limestone which is here visible, is a portion of an enormous series of beds, which are to be found in a regular position occupying the left ridge which bounds Glen Tilt, interstratified with quartz rock and with different varieties of schist. This regularity of position is destroyed wherever these beds come in contact with the mass of granite which occupies the right ridge before mentioned. Consequently, the limestone involved in the schist and granite now under review, is a portion of a bed the original position of which is perverted and lost. Are we now to suppose that this bed of limestone was originally deposited in its present form with alternating layers of granite? Admitting that the reticulating veins have been the consequence of a posterior intrusion, this cannot possibly be true of the laminæ, as independently of the difficulties, or impossibility as it may more properly be called, of such a process, it is plain that the simultaneous flexure and contortion of the laminated mass is the result of the disturbance produced by the granite veins, and consequently that it was deposited before the intrusion of those veins.* Must we then allow that there are cases where granite, or a matter resembling it, has been deposited like schist and bedded limestones from solution or suspension in a fluid? In the mean time, however, the igneous hypothesis respecting granite may perhaps allow of another mode of explaining this appearance. It is conceivable that a mass consisting of alternate layers of micaceous or argillaceous schist and limestone, a compound of which abundant examples are seen in the immediate vicinity of the rock under review, might be so acted on by heat

* Vide Plates 16, 17.

as to admit of the conversion of its siliceous layers into the substance now found interstratified in the limestone, while this latter resisting as it is well known to do, any change from the application of heat under such circumstances, might undergo no other affection than that softening which has led to its flexure and contortion.

The remaining appearances to be seen at this rock are more curious as adding to the unexampled confusion of the whole mass, than as offering any thing very new to the geologist in addition to that which has been already detailed.

Among the remaining substances entangled in this confusion, a large vein of felspar is the most remarkable. Its course is not long, nor does it appear to have any connection with the granite. It varies in colour through this limited extent, being sometimes white, at other times of a pink or dead lilac hue, and in some few places greenish. This latter colour seems to proceed from a mixture of epidote, which mineral is found in other parts of the rock in thin veins accompanying the granite and colouring the schist. Some massive garnet is also to be seen involved among the other substances, and it seems principally connected with the limestone. In a few cavities there occur crystals of flesh coloured calcareous spar, but so incomplete from the narrowness of the spaces in which they have crystallized, that I could not assign their figure. This I believe completes the catalogue of the minerals found in this singular place.

The granite is again seen crossing the river between this bridge and Forest Lodge, and near it lies a body of quartz rock which is evidently a continuation of some beds which may be observed in the hill above.

About 300 yards below the Lodge it crosses the stream again, and here the limestone is again mixed with it. A set of beds of a yellowish and greyish colour, resembling some varieties of foreign

marble, and exceedingly indurated, may be seen occupying a space of about twenty feet. If a careless view of these beds be taken, they will be found to offer what appears for the space of about ten feet, to be an alternation of granite in a very regular disposition with limestone. It has been mistaken for a real alternation. If this rock be more carefully examined it will be evident that it consists of a mere fragment, and that it is abruptly cut off where it meets the hill on the right, by abutting against the mass of granite. As the lower end dips under the water, a clear view of that part was not to be obtained when I examined it, but it appeared there also to be cut off by a granite vein. Those parts therefore of the granite which seem to alternate with the limestone can only be considered as portions of veins, the disposition of which, like that of trap veins in similar cases, has accidentally coincided with the direction of the limestone beds. If granite does really occur in beds, I know no reason to prevent it from alternating with limestone, but the appearance here is much too limited, and too doubtful in its origin to be admitted as an instance of such alternation. The granite which accompanies this junction may be seen in the bed of the river for seventy or eighty yards, after which it disappears. Three or four hundred yards of a blank alluvial space occur immediately after this, followed by a rocky space of about 200 yards. This rocky portion exhibits the following alternation, granite, schist, granite, limestone, succeeded by a general confusion of all these substances, and the granite which is in general limited to the right bank, now crosses to the left of the river. When I say that there is such an alternation, I do not mean that the several substances are bedded in this order, the case to which the term alternation is more properly applied. It is particularly necessary to attend to this remark,

and to ascertain the real nature of this kind of alternation, since it has been quoted at different times as proving a regular alternation between granite and schist, the limestone, as it happens, having been here overlooked. It is no further an alternation than because these substances, which in numerous other instances are confounded and irregularly mixed together, happen in this particular one and for a very short space, to have assumed a disposition accidentally more regular.* The question of alternation must rest on other facts than these. A blank of about eighty yards follows this rock, and is succeeded by one of the most remarkable junctions of the different rocks already described, which occurs in the course of the river. The main body of this compound mass consists of white limestone or marble, without any tendency to that regularly bedded form which is the general characteristic of the limestone in Glen Tilt. It is accompanied by a small portion of schist as well as by a mass of granite, with both of which it is variously intermixed. The marble itself is in most places of a pure white, a fine grain, and dry aspect, and is extremely hard. In some places it is of an ochry colour, and is interspersed by thin veins of the same substance, so as to resemble some of the palest and worst specimens of that marble known by the name of Giallo Antico. The schist which accompanies it is argillaceous and of a bluish colour, and the granite, both in the larger masses and in the ramifications, bears so near a resemblance to that formerly described that it is superfluous to describe it again. The veins which traverse the marble, like those at the bridge abovementioned, are of various sizes and are placed in every possible direction, but the ramifications are neither so numerous nor so minute as in that instance, nor is there any appearance of the laminated

* Vide Plate 14.

structure which occurs in the former. Where the marble is at the greatest distance from the granite it differs little or nothing in hardness or composition from ordinary specimens of this substance. But wherever it approaches or comes into contact with the granite it becomes highly indurated, effervesces slowly with acids, and gives on analysis a large portion of siliceous matter. In other respects there is no obvious change at the planes of contact, and the union between the granite and limestone is so slight that the action of the water separates them. The union of the limestone with the schist is much more intimate. Wherever the granite traverses both these substances together, which is generally the case where the schist is present, such a confusion takes place, that the boundary of neither can be defined, a troubled mixture and then a complete gradation between these two rocks being the result.*

On the right bank of the river above this rock a bed may be seen, consisting of a brownish hornstone, or rather a compact felspar, with a character somewhat porphyritic. It is one of that great variety of rocks associated under the general name of porphyry of which frequent examples occur in the course of the Tilt on both sides of the valley; more than I have thought it necessary to mention. These are sometimes considered as veins, and sometimes as beds; I believe that the former disposition is by far the most common, but their real nature is often so difficult to ascertain that I have been obliged to abandon the point in despair. The present one appears to be a bed.

I have purposely avoided noticing the rocks on both sides of the river which lie beyond its immediate bed, as they offer, on the right side at least, a succession so mixed and so confused, that any view of them which can be obtained in following the stream is nearly

* Vide Plate 19.

unintelligible. I may only say that schist, granite, and quartz rock of different aspects, with occasional masses of porphyry, succeed each other so frequently that the whole might be considered by those who are prepossessed respecting systems of alternation, as a demonstrable instance of this disposition. I hope to give a more correct view of their connections hereafter. On the left bank I may also generally remark that a succession of dark blue limestone, rarely interrupted by schist, quartz rock, and granite, is seen on the left bank from Poll Tarff down to this place, and even beyond it as far as Gow's bridge.

An alluvial blank of about 800 yards follows this marble rock, which is succeeded by 100 yards or thereabouts of granite; and after 150 yards more of an alluvial space, a large mass of rock for the space of 200 yards and upwards is found traversing and obstructing the stream, so as to form a cascade. This very irregular mass of rock consists of granite and quartz rock united. The quartz rock is of a peculiar aspect, being of a bluish colour, very uniform and compact and approaching near to common quartz in character, but still shewing evident marks of foliation. It is disturbed and intersected by the granite in a way which I need not now repeat. A thin stripe of limestone and schist may also be seen interwoven in the granite. Below the cascade there is once more a blank alluvial space of 100 yards, which is succeeded by quartz rock for about the same space; immediately after which occur about fifteen yards of a yellowish and greyish limestone or marble, very hard, and disturbed and traversed by granite in the way already described. This is followed by a series of limestone beds for about 200 yards, the first of which is blue and the last five or six of a yellowish aspect: these are almost the first limestone beds observed in descending the river which have the same general dip and position with the beds of the mountain on the

the left hand. But that position can only be called general, as in every instance all particular or minute regularity disappears wherever the limestone beds are found in the immediate vicinity of the granite. Nothing very remarkable is to be seen between this place and the entrance of the Criny. Near the point of confluence beds of quartz rock are distinctly seen crossing the river, and dipping under the limestone to which they are parallel.

Although various sections of the hills on each side are given by the streams which fall into the Tilt, few of them are sufficiently deep or explicit when singly taken to afford much information about the structure of the hills. The Criny however presents a section of considerable importance, which, as it illustrates the views that I shall hereafter give of the whole structure of this glen, may as well be described here.*

The quartz rock which I have noticed as crossing the river, may be traced through the chasm formed by this torrent, and it is found reposing on limestone, which is immediately succeeded by argillaceous schist. I am uncertain whether there is not a thin bed of schist interposed between the quartz rock and the limestone, and I have represented such a one in the engraved section; but it is not important, and the place is so difficult of access, while the confusion produced by the waterfall is so great, that it is difficult to make the investigation minutely. This alternate arrangement is found immediately reposing on the granite, and the schist being the bed in actual contact with the granite, is penetrated by veins precisely similar to those which have already been described. The limestone is here of a peculiar character, being mixed with quartz, sometimes in distinct concretions, sometimes in laminæ irregularly

* Vide Plate 21. fig. 1.

alternating. These veins originate in the mass of granite which forms the mountain, and this observation is important, as I shall hereafter shew that the granite seen in the Criny is a portion of the great central granite mass which forms the whole range of hills on the right bank of the Tilt.

From Glen Criny a succession of schist and quartz rock is to be observed, extending till within a few hundred yards of Gow's bridge; but the bed of the river being here inaccessible, we can only obtain a general view of it. The last bed of quartz rock in this direction is immediately followed by a bed of limestone, and this again is succeeded by an alternation of beds of schist, limestone, and quartz rock for some hundred yards below that bridge, together with masses of porphyry both of a reddish and a greyish colour, but whether disposed in beds or veins I have been unable to ascertain, though I imagine that they are beds, since they seem to conform to the stratified rocks. As this collective mass presents some interesting circumstances it will require a more minute detail.

The position of the whole of these beds is regular, with two very slight exceptions, and they occupy a space extending from 320 yards or thereabouts above Gow's bridge to 200 below it.

We have seen that all the irregularities of the beds take place wherever the granite comes into contact with them. Here there is no granite present, but, on the contrary, the mass of limestone of which these beds form a part, and which has hitherto been found terminating in the bed of the river, is continued to the right hand ridge, and may be traced high up in the hill, where the contact with the granite takes place.* The only exception with regard to the

* Vide Section, Plate 20. fig. 1.

granite, is that of one solitary and small vein, of a grey colour, which intersects the schist immediately above the bridge; the disturbance however produced by it is trifling. Another disturbance, although small in extent, is very remarkable, though not unique, since I have found a similar occurrence in Iona. Below the bridge on the left bank a bed of white marble is seen surmounted by a bed of hornblende schist. This is followed by a second bed of the marble about two feet in thickness, of which the greater part is suddenly cut off at right angles to the bed by a second mass of hornblende schist, while the lower part continues in the same direction, but bent, and of the breadth of only two or three inches. The lower part of the mass of hornblende schist, which thus intersects the marble, is also protracted in a thin plane continuous with the thin part of the marble and lying above it, while the upper side of the same becomes continuous with a regular and thick bed of the schist. Between these two portions of the schist there is interposed a thick bed of the marble, which is therefore included on three sides within the hornblende schist, its outer extremity being cut through at right angles by the schist. As the beds dip into the hill, the further progress of this extraordinary arrangement cannot be traced. A drawing accompanies this description, which words can scarcely render intelligible.* The appearance now described is interesting, since it is connected with phenomena of no very uncommon occurrence, which have given rise to much controversy. It is evident that both the prolongation of the limestone and that of the schist bear a great resemblance to the veins, which, in the case of granite, may be traced from a mass of that substance into the neighbouring rocks: yet there is no doubt that both the lime-

* Vide Plate 22.

stone and the schist are stratified rocks. I have observed the same appearances in clay slate, and they are frequent in the islands of Scarba and Jura, where this substance alternates with quartz rock, and where great contortions of these rocks have occurred. A more remarkable example occurs in a rock which constitutes one of the numerous beds of which Schihallien is composed. This rock is a micaceous schist, containing imbedded fragments of granite and of quartz rock, often of considerable magnitude. The larger fragments of quartz rock are sometimes partially split at right angles to its laminar structure, and these fissures are filled with the substance of the mica slate, putting on the same pseudomorphous appearance of a vein. I have found similar veins of red sandstone in the limestone of Arran, and they have also been seen in trap. But in a paper on Kinnoul I have described and delineated a specimen from a very extensive set of appearances of this nature, where a schist of the graywacké character becomes prolonged into ramifying veins in the interstices of a trap rock by which it is broken and disturbed. It is unnecessary therefore to enter on the subject in this place, but it will be sufficient to say that such pseudomorphous veins must be considered as portions of the strata, which, during their soft or softened state have been forcibly compressed and elongated into that form. The appearance occurring at Schihallien might obviously be produced by the mica while in a loose state in water, falling into and occupying the open spaces of the fragments deposited with it; and, in a similar manner, rifts in limestone might have been filled by the loose sand which formed the surrounding strata. The explanation of the other circumstances which occur at the junction of the limestone and hornblende schist which has given rise to these remarks, will be as obvious to those who shall inspect

the drawing as it is to me, and it is probably not very obvious to any one.

It is not far from this place, and on the left bank of the river, that a greenstone vein may be seen traversing the strata at nearly right angles. It is the only specimen of genuine greenstone which I observed in Glen Tilt, and it appeared to me to resemble those veins which are found in Cruachan and in the neighbouring mountains, where they also frequently assume a porphyritic aspect. Still however they differ considerably in their general appearance from those greenstone veins which are most usual in Scotland, and which are found to predominate in the vicinity of the larger formations of trap in the Western islands, and in many well known parts of the continent of Scotland.

The great mass of limestone which we shall hereafter find forming the whole of the left boundary of Glen Tilt, is of a dark blue colour, with one or two exceptions which I have already described in the progress down the river. But the beds at this place are of various colours, and offer some of the most beautiful ornamental marbles which Scotland has yet produced.*

The basis of nearly the whole is a white, rather larger grained, and crystalline marble. Beds of this variety occur in a pure state, and of considerable dimensions. But as all these marbles contain more or less of mica, with which substance they are interstratified, the white colour is seldom pure, being mottled with the slight grey tint which mica in similar cases always produces. It cannot therefore be considered as a statuary marble, since modern artists, ac-

* Having pointed out the circumstance to the Duke of Atholl two years ago, quarries are now opened in them, by which the numerous varieties which they contain have been more completely brought to light than they could have been by the operation of a mineralogist's hammer.

quainted with the beautiful stone of Carrara, have confined their labours to this more perfect variety. It is however perfectly applicable to various architectural as well as œconomical objects. A marble perfectly similar to it has lately been imported from America for the same purposes, to many of which its greyish hue and low tone of colour are more applicable than the dazzling white of Carrara. It is of a larger grain and a more compact texture than the Pentelic, with which the beautiful and interesting remains imported by Lord Elgin have lately made us acquainted. But the Pentelic marble, like that of Glen Tilt, contains mica, and from this contamination arises its fissile nature, to which we unhappily owe so much of the injury which these wonderful works have suffered. When polished, the two can scarcely be distinguished from each other; the difference in the size of their grains disappearing, and the grey and watery stains, with the brown stripes of the micaceous laminæ, equally characterizing both.

The discovery of statuary marble in the British dominions has been long a desideratum, but having already in the present volume discussed this question, I shall only briefly remark that how much soever we may admire those wonderful sculptures by Phidias which have been executed in a marble scarcely differing in colour or quality from this of Glen Tilt, we are very well assured on examining the progress of art in Greece, that the marble of Pentelicus was only used in the deficiency of a purer and more uniform stone, and that it was abandoned when later discoveries had made the sculptors of that country acquainted with a better class of marbles. It would be a fruitless attempt to introduce the marble of Glen Tilt, or even those whiter varieties which Scotland produces, in competition with the exquisitely beautiful and easily wrought stone of Carrara,

as long as these quarries remain accessible to us. For that higher class of sculpture on which the powers of genius are exerted, the proportion between the price of the wrought and unwrought article, (to use commercial phraseology) is so unequal, that no difference in the value of the raw material can compensate for even the most trivial defects in its quality. But there remains even in the class of the fine arts a great number of uses to which the marble of Glen Tilt might with advantage be applied. Such are all those works in architectural decoration, in which absolute whiteness and uniformity of colour, are not only unnecessary, but from their dazzling effect even injurious. The subdued tone and slight air of antiquity given to this marble by its stained and unequal colour would in these works render it of the greatest use. Its durability for the purposes of interior architecture must also be equal to that of Carrara, although there is little doubt that when exposed to the action of the weather it would like the Pentelic be liable to corrosion in those parts which abound in mica.

Besides mica, steatite and noble serpentine are found mixed with the white marble. The colours of these substances offer various gradations from bright yellow down to the darkest sap green. It is by these admixtures that the green and white marbles which form by far the largest portion of these beds are produced. The colours are so variously mixed, blended, and dispersed throughout the stone that numerous varieties are the result; and these are further increased by the occasional presence of dark lead blue. This mixture of serpentine with marble is by no means uncommon in Scotland. On the contrary it may be said that all the white marbles found in this country contain it in a greater or less degree. It is common in the white marble of Sky and in that of Balahulish. In that of Assynt it is more rare, but it occurs also abundantly in a

white marble which I found in Glen Fernat, not far from the junction of the Brerachan with the Airdle. The well known ancient green marbles owe that colour to the same admixture, which indeed in the Egyptian green and the Verde antico, is such that the calcareous matter is overpowered by the serpentine. The aspect of the green marble of Glen Tilt is however perfectly different from that of any marbles ancient or modern which have yet been wrought, and it offers therefore a valuable addition to the arts as well as a new commodity to the list of our mineral productions. I may add that, with a similarity of composition, many specimens bear a considerable resemblance both in character and colour to some varieties of the Cipolino of the Italians. Two other distinct varieties of marble occur where the calcareous beds terminate. The one is of an uniform ochre yellow, but of a much paler tint than the *giallo antico;* the other is of a flesh colour graduating into dark blue, but neither of these beds is of great magnitude.

The extent of the limestone which I have now been describing is considerable. The mass is of great thickness, and from the obliquity of its section a very large horizontal surface is exposed. As the beds run towards the north they may be traced to a considerable distance up the hill on the right of the river, but dipping to the south they plunge into the opposite hill and disappear. Independently of the steatitical matter which is mixed with this rock, some interesting minerals are found imbedded in it. The beds where they come in contact with micaceous schistus contain so much mica that this latter becomes at length the predominant substance, and there is then a perfect transition from micaceous schist to marble. In these cases it is raised in thin flags of great extent; between these flags there are often seen beds of steatitical clay, of a pure white or greenish hue, and often of considerable thickness. In the

same situation may be seen thin beds of a compact pale green and transparent steatite, and irregular lumps of the same substance are frequently found dispersed about the beds.

It is rare to find distinct pieces of noble serpentine of any magnitude, but they are also met with, and of a transparency and greenness equal to that of the well known specimens from Iona.

Talc of various colours, white, lead-blue and green is likewise met with among the marble beds, but in small quantity: and asbestus, although it is seen here and there in considerable pieces, may also be considered rare. But it produces abundance of tremolite, and offers some interesting and uncommon varieties of that beautiful mineral.

Of these, the first is fibrous and very compact, having a slight purplish tinge, particularly when viewed according to the axis of its crystallization. It is imbedded in the rock, with which it is perfectly compacted, presenting on fracture a small stellated or a longer radiated appearance, and giving a peculiar character to the marble.

The next variety consists of a congeries of regular prismatic crystals, varying from a tenth to a sixth of an inch in diameter. These are seldom radiated, but most commonly form a dense mass of which the crystals are irregularly interwoven together, and sometimes curved. Thin beds of this are found between the marble beds, and in some cases the crystals have shot in cavities so as to present terminations, which, however formerly complete, have been spoiled by the action of the water on them.

It is well known to mineralogists that many substances when found in the earth are in a soft state, and only acquire induration when removed from their native beds. If we are to believe Patrin the same is true even of the beryl. It is so with the tremolite which I have now described, which is exceedingly soft and flexible when first up, but hardens after some days of desiccation. The asbestus taken

which I found here is likewise so soft that it may be wrought into a paste with the fingers, but it acquires in a few days a hardness equal to that of fir wood. I have observed the same fact in the disthene which I collected at Boharm in Bamffshire. It is worthy of remark that the reapplication of water does not restore these minerals to their flexible state. We have yet to learn the chemical explanation of this circumstance.

There is no novelty in the fact I have here brought forward, but sufficient attention has not perhaps been paid in geological writings, to this differing condition of many strata as they exist in the earth, and after they have undergone that change to more perfect induration which they acquire after being removed from their native places and exposed to the air. With regard to many rocks used for œconomical purposes it is notorious even to workmen. It is easy to see how this circumstance affects many of the reasonings which have been brought forward on the consolidation of strata; a condition of which we see perpetual examples before us, without any ground for supposing that the agency of heat was conducive to that end, and in circumstances indeed where no agency of heat can be imagined capable of producing the complicated effects which have resulted. We are too little acquainted with the chemical laws which regulate the affinity of earths in a state of extreme division, to decide on results which may or may not be produced from either solution or suspension in water. One solitary fact well known in the potteries showing the strong affinity which exists among earths in such a state of extreme division and suspended in water, is sufficient to suggest to us the possibility of affinities still more intense existing among earths in similar circumstances, when their proportions perhaps are different, or where, in addition

to a more minute division, many of them may perhaps also be in a state of solution. On a small scale indeed examples of stony matters so formed are not wanting in nature. Such are the hard deposits of calcareous and other matters in water pipes, and in vessels at no greater temperature than that of boiling water. It is easy to see in the case of the semi-indurated strata, and of the soft minerals above described, how the further abstraction of the water in which these affinities were first brought into action, may by increasing them in consequence of the nearer approximation of the earthy particles, induce that stony hardness which these substances acquire in drying.

A third and more beautiful variety of tremolite is also found here. This like the last forms thin beds interposed between those of the marble, and occasionally also entering as a constituent part into the stone. It is that well known variety which so much resembles spun glass, that this comparison forms the best description that can be given of it. It is generally of a pure white colour, and is radiated in stellated forms varying from an inch to two feet in diameter, and exhibiting specimens of uncommon magnificence. I could not perceive that any of the specimens of this variety were so decidedly flexible as the latter, although they were taken from the bottom of the river, but there was still a very sensible difference in their power of cutting the hands and entering into the skin when first taken up, and after they had been kept for a few days.

More rarely the same fibrous and silky variety is found passing through all the shades of colour, from a pale to a very dark sea-green, and these latter specimens are particularly marked by the crowded and beautiful groups of their small stellated radiations.

At no great distance from these beds and in a similar position, a fourth and hitherto undescribed variety is also found, constituting a

bed of two or three feet in thickness. In its general aspect it so nearly resembles a granular quartz as to be at first sight difficultly distinguished from it. As it produces no effervescence with acids, it probably contains no great mixture of carbonate of lime, and may therefore be considered as a granular tremolite. It may be distinguished from quartz by its superior lustre, translucency, and specific gravity, as well as by its inferior hardness. The sp. gr. of the specimens which I tried was 2,840.

A fifth variety is found in the same place, but without so very marked a character as that of the one preceding. It is foliated, with a slight tendency to a fibrous structure, and forms large concretions in the marble. Its aspect is vitreous, and it is of a greenish grey colour.

Another modification of this beautiful mineral which occurs here can scarcely be considered of sufficient importance to constitute a mineralogical variety. It splits into thin laminæ, of which the flat surface has the splendour and almost the uniform smoothness of white satin, but on examination it is seen to consist of very minute fibres of tremolite interfoliated with very white and compact carbonate of lime. Some specimens are again found which seem to consist of a mixture of tremolite and schiefer spar, a substance which is also found although but rarely, among the calcareous beds.

The various forms indeed under which the several mixtures of tremolite with the surrounding rocks occur are such as to elude description, and not a little to puzzle a mineralogist. I shall only enumerate two more of the most remarkable. One of these is a compact schistose rock in which the union of the tremolite with the limestone is so intimate that it can only be distinguished in the first instance by its hardness and specific gravity, as the eye cannot detect the mixture. In the other the tremolite is mixed with a kind

of steatitic slaty marle, very friable, of a snow white colour and great specific gravity.

Associated with this limestone and in a similar position, I also discovered beds of sahlite, a mineral of considerable rarity in this country. These vary in thickness from two inches to a foot and more, and are sometimes intimately mixed with thin laminæ of the fibrous variety of tremolite. This mineral, from its superior hardness, resists the action of the water of the river better than the limestone does with which it is interstratified, and may therefore be distinctly traced projecting from those beds of which the calcareous portions have been more or less worn away.

The beds of sahlite may be seen extending for a space of from fifty to a hundred yards along the bank of the river at the same place. Considerable variety of aspect occurs throughout their course, from a greater or less intermixture of calcareous matter with the pure sahlite. Thus, like the more common specimens of this mineral it sometimes effervesces with acids, while in other cases it appears to contain no uncombined calcareous matter. When it is unmixed it resembles at first sight the whiter varieties of felspar, exhibiting a large platy fracture, and a similar lustre. In the angle of its fragment as well as in its specific gravity, hardness, and habitudes with the blow-pipe, it perfectly resembles the better known varieties of this mineral. As it becomes more and more mixed with the calcareous matter its platy fracture first becomes less regular and gradually disappears, the mixed mineral however still retaining a specific gravity greater than that of the neighbouring limestone. Its sp. gr. varies from 3,153 to 3,246, the most purely lamellar being the lightest. It is invariably white with a slight tinge of grey.*

* I may here add that I have found this mineral in Glen Elg, and in a similar situation, but exhibiting different colours, the predominant variety being snow-white, and the more rare one green: I have also found it in great variety in Tiree and Harris.

I should not however conclude this account of the minerals which occur in this part of Glen Tilt, without mentioning that fibrous limestone is also found in some of the rifts, showing a little of that pearly and changeable lustre, for which the satin spar is so remarkable.

I have thought it unnecessary in describing either these or the other rocks which I have examined, to particularize the several anomalous mixtures of substances which are found about them, since they are extremely partial and generally limited to the vicinity of the junctions. They all appear to be of a mechanical nature, or at least to have resulted from the same causes which produced the several disturbances already described, and they offer no particular instruction, while at the same time they can scarcely be defined by words.

Quitting these marble beds and descending still the course of the Tilt, schist, quartz rock, and limestone, are seen alternating for about 500 yards. In one place a bed occurs in the quartz rock, forming a regular part of the series, but composed of the constituents of granite, these being sometimes disposed in a granitic manner, and sometimes possessing the foliated texture of gneiss. This is followed by a schist, which seems intermediate between gneiss and micaceous schist, having the aspect of the latter with its shining surface and even foliated structure, but shewing in the cross fracture the grains of felspar which belong to the former.

Proceeding further on, a great series of these thin beds may be observed, of which some on being broken present the aspect of true granite, inasmuch as the mica is irregularly placed and the laminæ of the rock, however foliated in position, are by no means foliated in structure. A fragment so broken as to be divested of its external flat form, would be considered as a fragment of granite

since it must be esteemed an essential character of gneiss that the mica should possess an arrangement, at least so far parallel, as to give the appearance of a foliated structure.

As whatever view we can take of this occurrence is followed by important consequences, it is necessary to consider it somewhat more particularly, and I shall first examine that case in which the gneiss is found alternating with the schist. We have already seen in numerous instances, that great anomalies take place in the aspect of the schistose rocks, as well as of the limestone, wherever they approximate to the granite and are traversed by granite veins, I must therefore premise that no such veins are seen in this place. The mass of granite is here indeed removed to a considerable distance, and the schistose beds are perfectly straight and undisturbed.

The general series consists of mica slate, alternating in a very irregular manner with hard argillaceous schist and quartz rock, and with a few beds of limestone. With these beds is found that micaceous schist which contains felspar, and which will probably be considered by most observers as a modification of gneiss. If then it be called gneiss, that rock alternates with quartz rock, clay slate, mica slate, and limestone, an anomaly at variance with the almost universally received doctrines respecting precedence in rocks. If we now turn our attention to those specimens which have the granitic aspect, I may remark that, however decided this character may be in some particular points about this place, I shall here lay no stress on it, as better examples can be adduced from the hills at no great distance. Although the granite, in the instances which I shall enumerate, occupies but a small space among the laminæ, its texture is perfectly granitic, and bears not the slightest resemblance to that of gneiss, since the mica is placed in all directions, and the portion in question, if detached from the neighbouring parts, could not be

distinguished in the generality of hand specimens from genuine granite: at the same time I must add, that it bears but little resemblance to veins. The neighbouring rocks furnish abundant examples of ordinary granite veins, which are readily distinguished from the present appearances by the decision of their junctions, while in this case a regular gradation exists between the granite and the schist, and no boundary to the former can be assigned. The appearance which I have now described is not limited, as I have just said, to this place: other examples of it may be found. Besides the loose specimens of it which are to be observed among the transported blocks on the hills which bound the left side of the valley, it is also of frequent occurrence through a large tract which extends from Blair to Dalwhinnie, and thence to the head of the Spey. The specimens seen in this direction frequently exhibit various and repeated alternations of granite and schist, from the thickness of three or four inches down to that of a quarter of an inch. The tract in question is wholly, or in a great measure, composed of hard argillaceous schist, graduating into schistose quartz rock and more rarely into micaceous schist, with granite veins dispersed here and there through it. Between the laminæ of these schists the granite is found graduating into the schist, many varieties of coarser or finer texture appearing in rapid succession in the space of a few inches. It is only by the comparison of a number of specimens that the true nature of the rock is discovered, and it affords a curious example of the facility with which false conclusions may be formed on this intricate subject. However parallel the laminæ of granite may be to those of the schist for a certain space, they invariably quit that direction when the specimen is of sufficient magnitude, and may be seen holding an oblique course through these laminæ, often indeed becoming true granite

veins in their course, and even crossing the layers at considerable angles. A rock observable at Garviemore illustrates this accident well. Here the transit of the granite vein through the schist is at right angles, and is attended with a flexure of the layers on each side of the vein, in a curve directed from the thickest to the thinnest part of it. At each side of the vein the granite passes from it between the laminæ of the schist, producing a partial effect similar to the more extensive one above described, and which has doubtless owed its origin to a similar cause.

The other case which I reserved for consideration, is that where similar beds of granite are found alternating with, and graduating into quartz rock. This alternation is visible in the bed of the river not far from the entrance of the Mark. But a much better instance occurs in the hill of Grianan on the right of Glen Tilt, where the transition from the quartz rock to the granite is so perfect that the boundary cannot be defined. I have met with similar appearances in the vicinity of Dalnacardoch.

In a paper which I presented to the Society last year, I described among several varieties of quartz rock, that, perhaps the most common of all, in which grains of felspar are found mixed with grains of quartz, neither of them being crystallized; and I then pointed out the distinction between this rock and granite, attempting to shew that it was a recomposed rock, and that it had been formed from the wearing of more ancient granites. Among the several transitions of quartz rock into mica slate, clay slate, &c. I did not notice this transition into real granite, as I had not then met with this appearance: it will add one to the number of those transitions. It will at the same time be obvious, that it can in no respect affect the account which I then gave of the nature and connections of quartz rock. On the contrary, as I have shewn that this rock be-

longs to the same order of rocks as mica slate, and clay slate, it will only serve to point out their concurrence in another common circumstance. It is perhaps almost superfluous to say that the transition, which I am now describing, of quartz rock into granite, is by no means a dubious one, and that it does not bear the least resemblance to the common variety above referred to, which has so often been mistaken for granite. It is perfectly crystallized throughout, the felspar, the quartz, and the mica, having that aspect and relation to each other which cannot for a moment be mistaken by any one acquainted with the characters of rocks. The aspect of the mica alone is so remarkable, and so different from its appearance when found in quartz rock, that it is sufficient of itself to distinguish this modification from every other. Before quitting this subject it is necessary to remark, that one of the transitions between the granite and quartz rock takes place at the junction of the latter with the great body of granite.

I have been thus particular in describing this singular rock, because it has often been confounded with gneiss, from which it is strongly distinguished in its mineral character, and because it is important that a substance of so much consequence in the system of rocks as this is should have its relations accurately ascertained, and should not from laxity of definition be introduced into a series with which it has no geological connection. Many of the Western islands offer examples of it in its most genuine form.

From the point last described, following still the course of the stream, nothing is seen for the space of a mile and upwards, but a continued succession of the same varieties of schist. These rocks are also found occupying the hills on both sides of the glen, as far as they are within sight of the river.

If there are any other remarkable varieties, or any peculiar cir-

cumstances connected with the schist which forms the bed of the river throughout this space, they were concealed from me. The channel becomes so deep and the sides so clothed with wood, that it is scarcely possible to examine the banks; and the bed of the river itself may safely be called inaccessible during nearly the whole of its remaining course to Blair. Within about two miles of Blair, however, at a point which is marked by a cascade and a small bridge, a large mass of yellow marble is seen crossing the river. It is, like that before described, of an uniform ochre colour, and like it, applicable to architectural uses. Lower down, near the junction of the Fender, where there is again access for a short space, the great body of blue limestone is found. This may be traced across the grounds of Blair, and in the bed of the Banavie, where it exhibits those minute reticulations of siliceous matter which I have already described. From hence it is again to be traced to the opposite side of the Garry, where it forms a great part of the green hill of Tulloch. On this hill, at Invervach, many of the beds are white, and resemble those already described at Gow's bridge, being interlaminated in a similar manner with steatitical clay, and accompanied by mica. But I have passed my proposed boundary.

Having anticipated no more of the description of the two ridges which bound Glen Tilt, than was necessary to understand the nature of the rocks which are seen in the bed of the river, I must now return to them, taking up the right hand ridge, or north side of the glen, at the place where I have now stopped.

That portion of the ridge which lies from Blair to Gow's bridge is so encumbered with wood in some places, and offers so little interest in others, that I am content to pass it by in a superficial manner, particularly as its more minute examination would throw

no light on those interesting appearances in the bed of the Tilt from which it is so remote, and which are the principal objects of this paper. It is sufficient to say in general, that it consists of the several varieties of schist already noticed, which will doubtless be found associated both with quartz rock and limestone, and reposing somewhere on granite, as the other parts which I have really examined are found to do.

On the declivity of the hill above Gow's Bridge the schist and quartz rock may be seen irregularly alternating with each other and with the limestone. On the hill Stron na 'Chro the green marble beds are found at a considerable elevation, associated, as they are below, with these rocks, being in fact the continuation of that series of beds, the dip of which however various in the quantity of the angle, is always in a southern direction. A little higher in the hill the granite occurs: it is of a red colour, and precisely similar in character to that which is observed throughout the bed of the Tilt, and which I have already described.

The burn Aldcriny having worn a deep channel in the rocks, it is easy to see the granite for a considerable extent *in situ*; and its connections which are visible at the lower part of the channel of the Criny having been described before, I need not here repeat them.

The granite continues along the ridge to Grianan, and is accompanied by quartz rock, of which the connection with the granite is unintelligible in the hill, however it may hereafter be explained by comparison with other observations. This rock itself is of a very compact and somewhat transparent quartz, containing irregular grains of felspar: it breaks in a flaky manner, and appears to consist of beds extended in a north-easterly direction, and dipping to the westward of north. It is impossible, however,

either here or in any other instance which I have met with, to give a correct description of the dips of the schistose rocks which occur in the highland mountains, without running into endless details, since they are perpetually varying. It is perhaps fully as useless as it would be laborious to the observer and tiresome to the reader. These beds, at least for a short space, lie on the northern bank of the granite mass, and stretch away in a south-east line to Cairn na 'Chlavhan and Connalach more, which elevations consist entirely of quartz rock. The granite continues still visible to the eastward in the direction of the hills, but ceases to be red. It is now grey, and shews a slight tendency to a foliated structure.

This peculiarity of structure, imperfectly as it is marked, is an object of curiosity. I have already described a quartz rock as passing by a regular transition to granite, and here the granite in the vicinity of the quartz rock is found to have a foliated tendency, a tendency which not improbably unites it at some point with the quartz rock, although I did not discover that point of perfect transition. On the same summits I also picked up a specimen of genuine gneiss, but did not discover whence it had come.

The hill of Connalach beg shews a summit of granite, but it is a small space surrounded by quartz rock. The granite here passes into a variety which, with the same general aspect, contains crystals of hornblende. The two varieties are perfectly continuous, as continuous as the red and the grey, which I have just described.

Here then we have, as in numerous other instances, a confirmation of the geological identity of common granite, and of that which is considered as a separate substance by the name of Syenite. However distinct these two rocks may be considered as cabinet specimens, there is no distinction in their habits and connections, nor have we any reason to believe that the æras of their formation are

different. It is also no less inconvenient than unnecessary and improper, that the designation of a granite vein, when on entering a schistose rock it acquires hornblende, should be changed from granite to syenite. This mineral ought to be regarded as accidental, and whether present or absent it makes no alteration in the rock considered as a mass, nor can it alter or affect the validity of any geological reasonings which may be deduced from the relations of the granite in which it is found, to other rocks.

It has with equal want of proof been said that granite of different aspects belonged to different epochas or periods of formation, and we thus read of newer and older granites, as if mineralogists had established criteria by which these several varieties could be referred to a prior or posterior æra. If the connection of trap, sometimes with primary rocks, sometimes with those which contain animal remains, gives a support to these speculations where the rocks of this family are concerned, there are no such connections between granite and the surrounding rocks known as to justify them in this case.

In this place as in many others different varieties of granite are found together, not forming veins nor distinct masses, but graduating into each other by an indistinct transition. The several colours succeed each other at the same time with as little order as do the aspects and proportions of the constituent parts.

The quartz rock appears again to the eastward of Connalach beg, similar in its aspect to that one last named, and after continuing for a few hundred yards, it is succeeded by another variety of granite of a small grain and flesh colour, which forms a large mass of the mountain.

A superficial view of this perpetual repetition of granite and quartz rock, would lead to the false conclusion that these two rocks

alternated, and that quartz rock was, as it has too often been considered, a modification of granite. This supposition I have elsewhere shewn to be unfounded, and that this rock is a member of those schistose formations which are found reposing on granite. I shall prove hereafter, that in this instance also the apparent alternation of the quartz rock is a deception, and that it is, like the limestone and the schist with which it really does alternate, superimposed on the granite.

I have in former papers presented to the Society, shown that the polarity of granite, or its power of affecting the magnet, is by no means so rare an occurrence as it was supposed. I may add to these observations, that almost all the granite found here possesses the same properties. But as this is a question involving some important considerations which would interrupt the chain of the present investigation, I shall consider it in a separate paragraph at the end of this paper.

As I reserved the mineralogical description of the granite which is found in the bed of the river in contact with the schistose rocks, till I had described the larger masses with which it is connected, I shall now describe it, as well as such other varieties as appear worthy of particular notice. I may here also say, that if a term be required for the purpose of distinguishing it from that granite which does not contain hornblende, it may be called syenitic granite; in treating however of its geological relations, I do not think it necessary to adopt so long a term, which it will be sufficient to use whenever it is requisite to distinguish its peculiar character as a compound rock. One advantage to be gained by the use of such a term will be, that the term granite will thus become a sort of generic term, including species, or varieties, which differ from the compound of mica, quartz, and felspar, and of which there are

instances to which no distinct denomination has been applied, as this term of syenite has been to those which contain hornblende. And since the granite of mica, felspar, and quartz, is sometimes found to contain here and there a solitary crystal of hornblende, with which in a series of gradation those varieties in which hornblende at length prevails to the exclusion of the mica are connected, it is impossible to define the point at which granite is to end and syenite is to begin: there is no difficulty in modifying the application of the adjective term. But another, and the principal advantage arises from the limitation of the term syenite to a rock of which the mineral character is much more constant, at the same time that it is in general very strongly distinguished from granite in its appearance. In its geological connections also it differs so widely that it is absolutely necessary to remove all chance of their being confounded together, since this rock is connected with the trap family, and is found in a position in which neither granite nor syenitic granite has ever yet been seen, namely, incumbent on the rocks of secondary formation.

To proceed to the description of the rock at the junctions formerly described. It consists chiefly of high red felspar and white quartz, of which the latter is generally in the smallest proportion, the compound mass containing obscure crystals of dark green hornblende. These are seldom in large quantity, more commonly they are thinly dispersed through the rock, and not seldom even in the largest masses of rock they are altogether absent. I have not observed mica in any of the granite at the junctions described, but in several parts of the hills the same rock, or one not to be distinguished from it except by this circumstance, is found to contain mica together with hornblende, which latter not unfrequently becomes excluded altogether and the simplest form of granite remains.

The various granites described as occupying the principal parts of the ridge, are also mixtures of quartz, mica, and felspar, differing however as much in colour and texture as they do in structure; to describe such varieties is not possible, were it useful. The chief varieties of the syenitic granites are found on the slopes which descend to the Tilt, and they are almost invariably of a grey and black colour, from the predominance of the hornblende: their texture is as various as their shades of colour, the crystals of hornblende being sometimes very large and decided, and imbedded as it were in a paste of quartz and felspar, while in other extreme cases the minuteness and mixture of the several ingredients is such, that the constituents can scarcely be discerned. In these cases the specimens have sometimes the fallacious appearance of the greenstones of the trap family. They may, however, be distinguished from these by attending to the white ingredient, which frequently consists of quartz with little or no felspar, while in all cases it contains quartz, a substance which is but rarely found in greenstone. They may generally also be recognized for what they really are, by tracing them for some space, when their characters will be found to become more conspicuous, either by the enlargement of the constituent parts, or by the admixture of mica, a substance which, except incidentally, is not found as an ingredient of greenstone properly so called. These rocks, like common granite and gneiss, frequently contain epidote as a constituent incidental part, and in this also they are distinguished as well from that syenite to which I propose to limit the term, as from the greenstone of the trap family, since epidote is but very rarely found among these latter rocks. They are equally distinguished from them by the frequent presence of another mineral which, as well as the former, is peculiar to the older rocks, Sphene. This is found in considerable abundance,

minute, but well crystallized and dispersed throughout the stone. It is by no means uncommon in similar rocks in Scotland, and occurs, among other places, in Criffel as well as in Braemar; and I may here add, that I have found it in specimens of Egyptian granite which contained no hornblende. I think it unnecessary to enter into any further details of this nature.

It is not far from the granite which I have now described, that the quartz rock with the transition into granite which I have already described, occurs, and it is not necessary to make any further observations on it in this place. At Craig Crocha the granite again makes its appearance; and here, as in other places, it passes by a gentle gradation into syenitic granite, that is, it contains crystals of hornblende.

It is quite superfluous to continue the details of the structure of this ridge with the same minute accuracy, as they will be found little else but a repetition of those which have preceded. It is not however the less important to give a general view of the whole, and I shall therefore state it to as wide a range as is necessary for understanding the structure of Glen Tilt, and the true nature of the interesting appearances there visible.

Ben Dearg may properly be considered as the most conspicuous portion of the granite which forms the basis of this range of hills. It is connected with the right ridge of Glen Tilt which I have now been describing, by a succession of granite and quartz rock, exactly similar to that already noticed. Pursuing the direction of the country across the Tarff to Cairnmuir and the head of Dee, the same succession gradually unites the granite of this tract to that which forms Cairngorm and Ben Avon, the great central granite of the Grampian hills, and the most extensive tract of this rock in Scotland.

There is no reason then to doubt that the granite which forms the

right ridge of Glen Tilt is part of this great mass, and it in fact constitutes its termination in a southern direction. To ascertain its connection with the quartz rock, it is necessary to compare numerous observations made on the slopes of the hills, and in the channels of the torrents where such connections are visible. I have already mentioned the very conspicuous junction visible at Glen Criny, and it would be tedious to repeat the rest of the observations from which the general conclusion is drawn. That general conclusion is, that the quartz rock is superimposed on the granite,* and that every instance of apparent alternation in these rocks may be resolved into this. The confusion which arises in the disposition of these rocks depends on two causes, the discontinuous arrangement of the quartz rock, and the irregular protuberances, into which the surface of the granite is formed. These latter are the cause of the semblance of alternation before noticed, both on the sides of the right ridge, and in the bed of the Tilt. In no instance have I discovered them proceeding to such a distance from the body of the granite as to deserve the name of veins, and assuredly they are not veins traversing the main body of granite, but on the contrary portions of its solid mass. The junctions therefore of the limestone and schist with the granite, which are visible in the bed of the Tilt, are not to be viewed as consisting in the passage of granite veins through those rocks, a phenomenon sufficiently common in other places, but as the points of junction, as I shall soon proceed to show, between a great bed of stratified rocks and a central mass of granite.

It is necessary for that purpose to enquire into the structure of the left ridge or southern side of Glen Tilt.

Beginning from Gow's bridge and ascending the hill at right an-

* Vide Pl. 20. fig. 3.

gles to the stream, a succession of limestone continuous with that at Gow's bridge before described is found to a considerable height in the hill. It will be useful to point out the general bearing of this great range of limestone. It crosses the hills at Lude, tending towards the south, whence it passes through the Glen of Fincastle, and across the valley of the Tumel. Limestone is again seen at Mount Alexander, and at the base of Schihallien, from whence it appears to proceed through Glen Lyon to the side of Loch Tay; but I have not been able to trace any connection between these detached places. Eastward it extends by the side of the Scarsough to Mar, beyond which point I am unacquainted with the country.

To examine it more particularly. From Gow's bridge up the course of the Tilt to Forest Lodge it is seen skirting the banks of the river, and alternating with schist and quartz rock, while in the places formerly described it joins the granite, and undergoes those disturbances which I need not repeat. From the river it extends upwards to a height of many hundred yards in the hill, although not so exposed that we can truly ascertain what alternations it may undergo through this space. Every where its course is marked by the most lively verdure, forming a strong contrast with the brown and barren aspect of those hills where the subsoil is granite or quartz rock. Anthyllis vulneraria, Cistus helianthemum, Satyrium hircinum, and other plants which affect calcareous soils, are found on the faces of these green hills.

This limestone is of a blueish colour, and almost always of a large grained fracture. Where it lies in contact with quartz rock, it is commonly of a harder texture than in more distant portions, and where it is about to alternate with schist it is often interfoliated with thin laminæ of micaceous or ar-

gillaceous slate. Although dark blue or grey is the predominant colour, it occasionally varies through different shades to pale grey and greenish grey, and its texture is equally liable to variations. It is a pure carbonat of lime with the exception of the colouring ingredient iron, containing no notable proportion of other earths, except where it is intermixed with the siliceous or argillaceous laminæ. The same is true of the white varieties, except that where they are much mixed with steatite and serpentine they yield magnesia upon being analyzed.

The dip of the beds is invariably to the south, but the quantity of that angle is not sufficiently constant to render its measurement an object of interest. It seems to vary from five to fifty and even to sixty degrees. In one place and one only I observed a considerable contortion of the beds, and in many others there are fractures and dislocations to be seen. Yet with such partial irregularities we may still safely consider the general parallelism and stratification as regular, and the dip as a medium constant quantity of perhaps twenty degrees. A few porphyry veins are found to traverse these beds, an appearance too common to call for any particular notice. Nor is it possible for want of marks to refer to the places where they occur. Contortions similar to those here described are not unfrequent in Scotland, and they have been often supposed to depend on the vicinity of trap or granite. They are however to be seen in many places where neither of these rocks can be found, and I have observed in the island of Sky* a series of stratified rocks of which the evenness and parallel horizontality is perfect, although they are traversed by trap veins of enormous magnitude and great frequency. No general conclusions therefore re-

* See the first paper in this volume.

specting a cause can be deduced from these appearances. The beds of limestone which I have thus in a general manner described on account of their perfect resemblance through their whole course, continue with scarcely any alteration as far as the burn of Glenmore, extending upwards to a height in the hill similar to that which they have at the western end of the ridge. The alternation of the beds with schist and quartz rock is however more visible on the sides of the Tilt in this part of its course; and at the river Aldianachie in particular, there is so be seen an alternation in this order; limestone, quartz rock, limestone, schist, limestone.* The beds of limestone do not cease at the burn of Glenmore, but after crossing it they are less continuously visible, while at the same time they lose the almost rectilinear course which their elevated edges have hitherto preserved. A bed of white marble is found among them at Fealair, and some rolled stones of pink marble in the channel of the river point out also the probable existence of a bed of this colour. Alternations of limestone with quartz rock and schist continue to be seen in this southern ridge of Glen Tilt towards Scarsough, but the pursuit being unnecessary for the purposes of this paper I made no accurate record of it. It is to be regretted on this account as well as many others, that no geogra-

* Rocks thus situated have by some mineralogists been divided into principal and subordinate beds, but however this distinction may occasionally be found to hold good with regard to some of the rocks so enumerated, yet as it is by no means a distinction universally existing, it ought not to be erected into a general rule, since it increases the number of artificial divisions, and offers a convenient and unmeaning phraseology instead of the language of accurate description. Subordination implying inferiority or dependence, it should follow that the one rock was in all cases either necessarily less in quantity, or in some way dependent on the other. The term *interstratified*, involves neither obscurity nor hypothesis, and is amply sufficient for the purposes of description, when combined with the relative proportions and positions of the rocks in question.

phical Survey of Scotland exists on which reliance can be placed. The errors are in fact beyond enumeration. It would otherwise be a desirable object to trace the real line of direction taken up by this elevated edge of limestone through the long course I have pointed out: but it must be reserved for future examination.

Resuming now the left hand ridge of Glen Tilt at the point where the limestone terminates, the remainder of the task of description is easy. The whole mountain of Ben Gloe is one mass of quartz rock, with scarcely any notable quantity of schist interstratified with it. It is the immediate boundary therefore of the limestone bed, and from the relative position of both, it must consequently be considered as lying above the limestone. The extent of this rock towards the east is considerable, since it stretches into Mar, and occupies a great part of Glen Shee. To the west it soon disappears, or at least its continuity is broken, since on the west side of the Garry it is only found in alternation with schist. To the south of Ben Gloe this rock is once more seen alternating with limestone, which is again succeeded by the mica slate, and this without further changes, except a gradation into clay slate, terminates at the well known boundary of the secondary strata near Dunkeld and Blairgowrie.

The contortions and the conglomerate aspect of some of the beds are the most remarkable circumstances respecting the quartz rock of Ben Gloe; the former proving that quartz rock, like the schists with which it is associated, has been in a flexible state, and the latter proving beyond doubt the partially mechanical nature of this deposit. Besides these it produces three coloured varieties of quartz, pink, amber brown, and blueish grey; the former equalling in colour the most beautiful varieties of that well known substance.

I have reserved to this place what remains to be said concerning

the rock which I have hitherto spoken of by the general name of schist. To have described the several varieties on all occasions where the geological history only was required, would have created much confusion, as they rarely maintain the same character for any considerable space. The most abundant is a clay slate, rarely fissile, and generally of a very compact texture and dark blackish blue colour. It sometimes possesses a glossy and unctuous surface, and passes into a sort of talcaceous schist. It is often also much penetrated with quartz, and on some occasions finely interlaminated with the same substance, very beautifully banded specimens of this variety occur near Gow's bridge. On some occasions it becomes intermixed with hornblende, which by degrees predominating, the compound passes into a hornblende schist similar to that which is so common in gneiss. This occurrence is frequent at the junctions, and here also the schist, even where it is merely argillaceous, generally displays unusual hardness. Hornblende schist is also found in beds unconnected with the clay slate.

Micaceous schist of aspects infinitely varied is also found in this ridge of hills. In general however it is characterized by the predominance of the quartzy ingredient, and in this way it passes into quartz rock by a series of gradations which cannot be defined. I have already had occasion to speak of those places where it assumes the character of gneiss, and need not therefore repeat the description here. I have only to add that green fibrous actinolite is occasionally to be found in this micaceous schist, a substance which, however radically identical with hornblende, is sufficiently distinguished in its appearance by characters which need not be detailed here. In some of the rolled porphyries which are found in the hills which bound this Glen I have observed pinite. This mineral

has not hitherto been found in Scotland, and as indeed it seems to have been as yet seen in only one or two situations besides the place whence its name is derived, it will not be superfluous to describe the specimens and the substance in which they are imbedded. The base of the porphyry is a brownish hornstone or compact felspar, containing numerous crystals of reddish-yellow felspar and a few grains of quartz, some of which appear to have the primitive form of this substance. Together with these, numerous crystals of pinite are imbedded in the stone, varying in diameter from one tenth to one sixth of an inch, sometimes of similar length, and at others mere scales. Brongniart describes it as having been found in porphyries, and I may add that the specimens which I procured differ in no respect from the foreign specimens with which I have compared them.

A similar porphyry, I may here say, is to be observed in Glen Shee. Oxide of titanium in a pulverulent or scaly and investing form, is also to be seen in the rifts of the quartz rock in Ben Gloe. The same disposition of this mineral occurs in Ben-na-caillich, near Killin, and it must not be confounded with oxide of iron, the more common metallic substance in rifted quartz.* Among the loose stones on the skirts of Ben Gloe I also found a singular substance. It is a laminated schist of which the basis is clay slate, occasionally mixed with hornblende and with quartz, and containing small lamellar and conchoidal scales of a crystalline white carbonat of lime. I know not how to describe this rock so well as by saying that the calcareous bodies are precisely like fragments of shells, and that the whole on a first view would pass for a shale containing shells; if found in a secondary country it

* I may here add that I have also observed rutile in quartz in the Scarsough mountain, and accompanied by oxidulous iron in the micaceous schist of Rannoch, so that it is not a rare mineral in Scotland.

would be thrown aside as a bad specimen of such a rock. I would not be understood to mean that the substances in question are really the fragments of shells, whatever general resemblance they may possess; but if considered merely as crystallizations they are sufficiently singular to be worthy of notice, since nothing analogous to them occurs in the different schistose rocks which I have examined in Scotland.

One other rock is yet deserving of notice which, although not precisely situated in Ben Gloe itself, is found among the beds which appertain to this great mass of quartz rock. It is visible in Glen Fernat.

This is a mass of porphyry intermixed with a mass of quartz in such a manner that it is impossible to ascertain precisely the relation which either of them bears to the surrounding rocks. There is however little reason to doubt that the quartz forms a vein, but I suspect that the porphyry also is disposed in a similar manner, and that the appearance in question is the result of the interference of two veins. In either case the porphyry as a mineral specimen offers an aspect I believe as new as it is difficult to explain. Its basis is the usual indurated claystone, or compact felspar, or hornstone if that term be preferred, which is the most common basis of the porphyries that occur among these strata. It contains distinct crystals of felspar, but together with these, fragments of quartz are also found in it. These are most obviously fragments not crystals. They are irregular, of different sizes from that of a pea to that of an egg, and their angles are sharp. In addition to that, where the porphyry and quartz masses are in contact larger fragments are to be observed mutually connected both with the porphyry and with the quartz. Porphyry has generally been considered as a crystallized rock, yet here it offers the mixed structure of a crystal-

lized and conglomerated one. The island of Arran indeed produces some porphyry which appears to possess a structure analogous to this, inasmuch as grains of quartz apparently rounded, not crystallized, are found imbedded in a common base with glassy and earthy felspar. But that structure might admit of dispute.

Such are the most remarkable of the independent facts which I have noticed in this tract of country. Let us now, rejecting all the minuter features which accompany this succession of rocks, extend our views over a wider range, and attempt to investigate their general bearing*.

The most continuous bed which has occurred in this view is the limestone. We have seen that it is regularly bedded, without any material disturbance, with an elevation somewhat varying and consequently in an undulating plane, and that it is continuous over a very large tract of country. We have also seen that its elevated edge is prolonged in a line which is straight for a great distance, and which perhaps may prove to be so even through a greater space, when an accurate survey of Scotland shall have been produced. It is therefore the most regular rock of the series now under examination, and may consequently be taken as the point of comparison for the others and as that from which the true relations of the rocks on each side of it must be investigated.

It is indifferent to the object which I have at this moment in view, whether the beds of limestone are considered as having been originally deposited in their present position, or whether by subsequent changes they have been diverted from one more horizontal. It will not be denied that they are deposited rocks.

If we now trace upwards from this continuous bed of limestone we shall find that it is followed by a large and continuous bed of

* Vide Map, Plate 18

quartz rock, and we have also seen that the calcareous beds themselves alternate with beds equally continuous of quartz rock and of schist. We have seen that the great mass of quartz rock is followed by a small bed of limestone, and that this again is succeeded by micaceous and clay slate, terminating the series of the bedded rocks in this direction. Here then is an order of rocks different from that which we are taught to believe universal, since the micaceous schist is far removed from the granite, and only follows a succession of limestone and quartz rock. It is the limestone which immediately follows the granite, and that granite is probably a portion of the great mass which forms the central granite of Scotland.

This contact of the limestone and granite is too well marked to admit of dispute, however, like many of the other remarkable circumstances attending on Glen Tilt it has been overlooked.

But there are other important phenomena which accompany the junction of the limestone with the granite. Recurring to the alternations between the limestone and the beds of schist and quartz rock with which it is continuous, we find that these alternations are regular, even, and defined. But if we now trace downwards to the granite, we do not find any one of these beds continuously in contact with the granite; on the contrary it is sometimes the schist, sometimes the quartz rock, sometimes the limestone, or there is a want of conformity between the granite and the rocks which lie above it. This is not the appearance which we ought to expect had the superincumbent strata been deposited on the previous basis of granite. If the granite had been the lowest of a series of deposited rocks and the basis on which the incumbent ones were precipitated or crystallized, all the strata which lie on it should have followed upwards from it in a regular order of succession. That rock which was contiguous to the granite in one place

should have been contiguous to it every where, since this law is invariably found to hold good among rocks of which the stratification is demonstrated. This observation is of importance, and I have illustrated it by two sections, the one showing the fact as it actually exists, and the other the order which should take place had the strata been regularly deposited on the granite.* In addition to the irregularity of this line of contact, symptoms of confusion and disturbance are apparent,† in every instance where the granite is actually visible in contact with the neighbouring rocks. These consist in a general mixture of all the stratified rocks with the granite, and a total discomposure of their regularity, being at the same time accompanied by the passage of minute veins from the mass of granite into the stratified rocks. Where on the contrary the beds lie out of the immediate vicinity of the granite, they retain their parallelism and regularity, its influence appearing to extend to a very short distance beyond the point of actual contact.

The real structure of Glen Tilt, and the true cause of the appearances which have excited so much notice, must now be seen so clearly to follow from the history of the rocks which bound it, that it is almost superfluous to give a summary view of the whole. I will however conclude this account with such a sketch, illustrating it by a map and such sections as may render the whole more obvious to those who may be inclined to follow me over the same tract.‡ The map does not pretend to minute accuracy with respect to every rock over this large space. It would have been in fact impossible to have laid down such details on a survey of this nature, the only one which has yet been executed of this district.§

* Plate 21, fig. 2 & 3. † Vide Plates 14, 15, 16, 17, 18, & 20 fig. 4.

‡ Vide Plates 13 & 20.

§ I am indebted for this Map to the Duke of Atholl, it being the survey of part of his estate, and executed by Stobie, the author of the General Map of Perthshire.

But however defective and however misplaced in point of distance many of the most remarkable boundaries can scarcely fail of being, it is sufficiently accurate in the general features for all geological purposes. The sections are necessarily general, and are given not as actual sections of any particular points, but as illustrative of the relative superpositions of the rocks.

The course of the Tilt may therefore be considered as bounded on one side by the outer edge of the granite mass of the Grampians, and on the other by the primary rocks which follow and are superimposed on it. These rocks consist of an alternation of limestone, schist, and quartz rock.

The bed of the river is cut upon the line of contact of these two separate classes of rock, lying upon the surface of the granite, and against the elevated edges of the stratified rocks.

Its action has in various instances exposed the junction of the granite with the stratified rocks, and these exposed parts are the confused mixtures in the bed of the river which have already been described

Although the river follows this line of junction in a general view, it does not follow it so accurately as always to keep the granite on its right bank, and the stratified rocks on its left.

For this reason the stratified rocks are sometimes seen crossing to the right bank, and even ascending high up the right side of the hill. The granite also crosses to the left in a few cases, but as it dips under the stratified rocks it is not found in the hill.

The Sections which are given illustrate this variation and explain its cause.

The apparent alternation of the granite with the stratified rocks is also explained by attending to this arrangement.

The granite masses which extend beyond the general surface of

the granite, and are found in the bed of the river, do not run to any extent through the mass of strata. It is therefore probable that they are not veins, but simply irregularities, of the granite.

The junctions of granite in the Tilt are not therefore the transit of independent granite veins like those of Portsoy or Rona, but the interrupted portions of a continued line of junction between a great surface of stratified rocks, and an equally extensive but irregular surface of granite.

Wherever this junction is found, a complicated disturbance of the whole rocks at the point of junction is seen, and small veins of granite are observed penetrating the stratified rocks.

In these places of junction the granite becomes so intimately mixed with the limestone as to alter its character, and wherever the granite is in contact both with schist and limestone, a similar mixture and transition between those two substances takes place.

In all other cases the schistose and calcareous rocks preserve both their regular disposition and their ordinary chemical characters.

I have reserved for a separate description some interesting circumstances relating to Glen Tilt, because they are extraneous to the general appearances, which required to be considered in one collective point of view, and because they would have interrupted the continuity of the narrative. The first of these is a deposition of calcareous matter, which was pointed out to me by the Duke of Atholl, to whose unwearied kindness and friendship I am no less indebted for the facility which I experienced in examining this district, than the science of geology is for this very interesting fact. On the brow of the hill above Gow's bridge a large bed of shell marle is to be seen. It is found on the left side of the river commencing under a face of limestone and extending for about 250 feet or more down the hill. It is between 80 and 90 feet wide, and its depth seems to vary from one foot to six or more. This appearance is unexpected but it is not solitary, as another similar instance occurs at the foot of the limestone ridge at the south of Ben Gloe, as well as on the hill of Tulloch formerly mentioned, but in neither of these cases so well marked or so extensive as the present.

The formation of shell marle in the peat mosses of Scotland is I believe well known to the Society, as it has long been to the agriculturists of Scotland. These deposits are by no means uncommon, whether in the larger tracts of peat, or in the smaller ones which are found occupying insulated patches on those hollows in the mountains which are favourable to the growth of this substance. They are found forming beds, generally of no great thickness, but varying from an inch or two to as many feet, and lying under the

covering of peat. The calcareous matter is commonly small in proportion to the clay, sand, and other foreign substances which they contain, in so much that they are seldom of any value to the agriculturist. A few which I examined were found to contain from ten to fifty per cent. of carbonat of lime; and independently of the clay and sand which enters into their composition, they are usually blackened by a mixture of half decomposed and carbonized vegetable matter. It is easy to perceive from the flatness of their surfaces and their tolerably uniform thickness, that they have been formed at the bottom of water in lakes of different dimensions, which have been gradually obliterated, partly by the influx of earth, and partly by the growth of those well known vegetables which have covered them with their present stratum of peat. In the instances which I have had an opportunity of examining, the shells from which this calcareous matter has originated have been either so thoroughly decomposed, or from their tender structure so mutilated and broken, that I have never been able to collect a specimen capable of being ascertained. Other mineralogists however have examined the shells found in these beds, which were long since known to the late Dr. Walker, and of which an account has been given in some of his works.

The formation in question is of a nature entirely different, and has never yet been noticed by mineralogists: its novelty at least renders it a matter of some interest.

Where the great limestone bed, which I have described as occupying the southern side of Glen Tilt, is about to meet the quartz rock, it forms a range of small abrupt faces or scarps extending in an interrupted manner for perhaps a mile. These may vary from ten to thirty feet in height. In wet weather small streams fall in cascades over them in two or three distinct places;

and generally the surface-water from above trickles down their faces. In these parts, thus subjected to the action of water, the limestone is dissolved and deposits here and there a white crust of carbonat of lime resembling the usual deposits of calcareous waters, so as to whiten in many places the surface of the rock. One cascade of considerable height has thus left the marks of its intricate course in the dark and broken rocks so perfectly, that even in dry weather it appears to be always flowing, and only a narrow inspection discovers it to be an imitation; a painted cascade formed by the hand of Nature. I have been the more particular in describing this fact and its extent, for the purpose of showing that the marle bed is not produced by a deposition of calcareous earth from the water thus impregnated. Were this the case it should be found under the whole extent of this range of rocks, whereas it is limited to one spot and that one a point where the water flowing from above is diverted from it on each hand by sinuosities in the scarped face. I do not assert that there is absolutely no other deposition of a similar nature in any other place throughout the great extent of the limestone range of Glen Tilt, but after a considerable search I did not find any in those neighbouring parts where the surfaces of the rock were whitened, and the greater flow of water would have led me to expect it, had it been a mere deposit from water. There is little doubt that a portion of the lime contained in the bed has been produced in this way, but that portion must necessarily be small, or the same earth would be easily discovered in the soil of the immediate vicinity which lies in similar situations, which has nevertheless only the ordinary aspect of the whole mass of soil incumbent on the limestone. On examining the nature of this deposit it is found to consist of a substance much more spungy and loose than chalk,

although on a first glance strongly resembling its more friable varieties. It is soluble without residuum in muriatic acid. On a narrow inspection it is found to contain minute fragments of shells, particularly towards the surface, while deeper in the bed all marks of organization disappear. It is also every where penetrated by the fibrous roots of grasses and other plants, or by the minute channels which their decay has left. It does not acquire any induration on drying, as the specimens before the Society will show. On the immediate surface, or at small depths where the decomposing causes have had less time to act, entire shells are found, and numbers of these may be collected in a very perfect state. Among those which I did collect I only found the following in a state sufficiently entire for examination.

No. 1. Helix arbustorum.

2. Appears to be Helix *rufescens*, or *hispida*.

3. Two broken specimens, of which I cannot speak with the least decision.

4. I conjecture it to be Helix fusca of Montagu; and perhaps it agrees with Draparnaud's genus *Vitrine*.

5. A small Planorbis; but of what species I am unable to determine.

6. Appears to be a minute Lymneus; perhaps Lymneus minutus of Braard.

All appear to be terrestrial shells.

This then is to be considered as a land formation of calcareous matter, if we may use such a term, and the result of the successive renewal and death of these minute animals for a length of time unknown. Whether this process is still going on I was unable to discover. After much search I did not find any living animal, but among the helices were some with their colours so perfect,

that their death could not in all probability have long taken place. As the animals themselves are known to be existing species, it is indeed probable that this bed is still in a state of increase, however tedious and imperceptible the process may be.

Here then we have a fact which presents us with another modification of those strata which owe their origin to the action of living animals, or to the accumulation of their remains. It has always been known that marine animals acted an essential part in the production of the secondary, and even the latest of the primary, (or *transition*,) strata. It has lately been shown that considerable deposits and large beds of rock have also in former times been produced by testacea inhabiting fresh waters. But it has never been suspected that similar deposits could be formed on dry land. That such is the case here, is sufficiently evident from the angle of acclivity on which this bed is formed, on a surface which has assuredly undergone no alteration of its position since its formation, or at least since the formation of the granite. The fact itself is much too insulated and too narrow to admit of any generalization, or to justify us in supposing that similar formations might have taken place in a more ancient state of the globe. Else speculative minds might conceive that of the numerous elevated and apparently displaced strata which are now found containing organic remains, of which, not only the species, but the very genera as well as habits are unknown, some at least might have been derived from land animals, whose remains were converted into rocks in the very places where they now exist. Should causes with which we seem but very imperfectly acquainted at present, hereafter convert the marle bed now described into a rock, and all traces of its recent formation disappear, a circumstance at least within the limit of possibility, assuredly future geologists would

not be a little puzzled to reconcile its appearance with that of the surrounding rocks, of which the intricacies already described in this paper, are sufficient in themselves without the further addition of such a deception as this.

It were to be wished that this specimen could be preserved for the future examination of others, but the wants of agriculture must be satisfied, and the pick-axe and spade have already commenced their depredations.

The next appearances in Glen Tilt which I consider worthy of notice, and which are extraneous to the general structure already described, are the marks which it bears of the action of water. If we consider the general characters of the rocks which form the opposite sides of the valley, and attend to the section which accompanies the description, it will be seen that the channel of the river during the greater part of its course, is cut upon the junction of the stratified and the unstratified rocks; in consequence of which those junctions which form so material a part of the interest of this valley have been exposed. It is easy to conceive that a longer continuance of the same action may expose a greater portion of this line, and ultimately lay bare the granite which doubtless lies below the stratified rocks beyond Glen Criny or Gow's bridge down the course of the Tilt. If from future probabilities we ascend to past ones, we may imagine the river once flowing at a higher elevation, and gradually making its way on the surface of the granite and against the edges of the soft strata; the former offering a constant resistance, while the latter, giving way to its action, have formed those precipitous faces the displaced fragments of which have during the progress of time been rolled along the valley to the course of the Garry; being destined in their ultimate progress to assist in forming the immense beds of alluvium which

mark the course of the Tumel and the Tay, and to exclude the sea which once flowed high up into the present estuary of the latter river.

The actual corrosion produced by the mountain torrents is most strongly marked in those which fall from the skirts of Ben Gloe to join the Tilt. It is easy to perceive in these, that the fortuitous inclination of the strata has not produced the intervals now occupied by the streams, but that beds once continuous have been cut through often at right angles to their direction, leaving their sections fairly exposed in the deep beds of these powerful agents. The depth of these sections is always striking and frequently enormous, exceeding an hundred feet; with sides almost perpendicular, while the dark and turbulent water roars, seldom visible, and scarcely audible, beneath. In the progress of waste and ruin the falling of the upper parts gradually produces a more open chasm, destined perhaps in the progress of time to form a glen such as those narrow and prolonged ones which constitute a frequent feature throughout this district.

To what extent these agents actually operate in changing the present surface of the globe, is an enquiry beyond the objects of this brief notice, but we have, in this valley as in numerous other parts of this country, abundant proof, that many of the most conspicuous and extensive alluvial deposits have had their rise in causes of a much more general and extensive nature.

Of this a very remarkable example is to be seen near the farm of Auchgowall in the lower part of the valley, extending to Gilbert's bridge. It is most conspicuous on the left bank, where it is seen covering all the hills to a considerable height and a great depth, its thickness being distinctly shown by the sections of the streams which descend to join the Tilt, and of which the courses are

marked by extensive ruin: the bare schistose foundation has also been in many places exposed. The alluvium in question consists of the materials of the surrounding country, but all of them water worn and mixed with sand and gravel as from considerable attrition. In this, as in numerous other examples, there is no assignable mode in which the materials could have been either formed, or deposited, by the slow action of the existing streams, while the total absence of a similar deposit in other parts of the valley equally subjected to similar causes, bespeak a different origin. The cause appears to have been of a diluvian nature, and the determination of the deposit to this point, may perhaps be found in the form of the valley at this place and the obstruction which it has offered to a mass of matter impelled through the upper parts where no such obstruction to its deposition existed. Such an obstruction as that which I have suggested might formerly perhaps have been rendered more complete by the continuity of the strata beyond this point, which has since been gradually destroyed by the slow action of the Tilt: in consequence of this the deposit of alluvial matter has itself gradually diminished, sliding successively down the hill as it has been undermined, and together with the more gradual abrasions of the land in the upper parts of the valley, hurried by the daily course of the river to the Garry.

The probability of this supposition is strengthened by the occurrence of a similar circumstance at no great distance. This may be seen near the junction of the Garry and the Tumel in the hills above Fascally; and the deposit is here also of enormous thickness and of similar materials. Like that in Glen Tilt, it occurs where the valley appears to have favoured the accumulation of a diluvian deposit, and where the subsequent action of the river in its rapid and corroding progress downwards as it runs through the narrow

openings at Killicrankie, has hitherto proved insufficient to undermine and remove it; in consequence as it would seem of the lateral direction of its course produced by the fall of those portions of alluvium which have formed the small holm on which Fascally is situated. Thus it is for the present protected from change, and perhaps destined to remain, for a longer period than that in Glen Tilt, a monument of those revolutions which point out an extensive but transitory action of water on the surface of our globe.

I have remarked in the preceding paper, that the granite which forms the right boundary of Glen Tilt has the property of affecting the magnetic needle. This influence is far from inconsiderable, and in many cases produces not only remarkable local variations, but a disturbance of that instrument so great as to render it useless for the purposes of ascertaining any meridian whatever. It is not limited to the syenitic varieties, where from the predominance of hornblende we might reasonably expect to find it more active, but is equally to be found existing in those granites which do not contain this ingredient. Neither does it depend apparently on the micaceous ingredient, since in many of the rocks which shew it strongly the mica is in very small proportion. It seems to be equally independent of a state of decomposition in the granite, since it is here, as elsewhere, to be found inherent in fresh specimens, although on the summit of Goatfell in Arran, as I have remarked on a former occasion, it appears most conspicuously in those specimens where the iron is becoming carbonated and the rock is tending to disintegration. In the paper to which I here allude,* I noticed this fact as being nearly a solitary one at that time, but I have had occasion to observe it since on various occasions. In a paper on Cruachan, drawn up

* Geological Transactions, vol. ii.

three years ago, the same circumstance is described, and I may here repeat that the granite in question is not decomposed, and contains a very large proportion of flesh coloured felspar, the quartz and mica being in small quantities. As granite is a rare rock in Scotland, I have not been able to extend my observations on this substance far, but I have also found the same magnetic power in some of the granites which form the Ross of Mull. The porphyries also occasionally possess the same power. I have observed it in different places, but most remarkably in those of Cruachan, and expect that it will be found most conspicuous in those, which from their black colour contain much hornblende and approach to trap in their composition: it is not always that circumstances allow of the repetition of these observations. I have not often discovered it among the primary schists, but I must add at the same time that my trials on those rocks have been but few. Yet it occurs among the schists in the hills which border Glen Tilt in more situations than one, although seldom in an energetic degree. It is not limited to the hornblende slate, but is found in those specimens of argillaceous schist into which that mineral does not enter. I have also observed that some of the beds of dark blue limestone exert a disturbing force on the needle, and imagine that I found it greatest in a stratum which crosses the upper part of Glen Fernat at the foot of Cairn Ree. I have however examined limestones of the same apparent nature in other parts of Scotland without having discovered a similar property in them, so that I conclude it will be found but rarely either among the rocks of this family, or the schistose ones.

It has so long been known and so often remarked as a quality common to the rocks of the trap family, that instances of it must have occurred to every geologist. In these indeed it is often so

conspicuous as to have become an object of popular curiosity, notwithstanding which, it has rarely attracted the attention of geologists, unless, as in cases like those here alluded to, it has been exerted in an uncommon degree. I may therefore add that it is very generally diffused among the rocks of this family, although as we might reasonably expect, in very different degrees, those variations of energy depending at times on the peculiar composition of the rock, at times on its state of decomposition, and at others on circumstances which we have not the means of ascertaining, little acquainted as we are with the laws which regulate the movements, the accumulation, or the permanence, of this mysterious power. In a paper on Canna,* which I presented to the Society some years ago, I pointed out the great action exerted by the trap in several parts of this island, as well as in that spot so well known to the inhabitants and to mariners by the name of Compass-hill, and took occasion at the same time to recommend to surveyors who are in the practice of using the magnetic needle in their art, the necessity of attending to these disturbances hitherto held of no moment, or rather, I might say, unknown and unattended to by them. I also pointed out with similar views the same effects occurring in several parts of the island of Sky, where they are frequent and powerful. Among the places in that island where the needle undergoes violent disturbances the hill of Glamich is the most remarkable, but as in that paper† I have entered into the details which respect this spot, I need not repeat them here. I must however add that this hill consists partly of clinkstone, together with the porphyries which are usually associated with it,

* This paper does not appear, having been retained for the purpose of connecting it with the history of the neighbouring and similar islands.

† Printed in this volume.

and partly of that syenite which appears to belong to the same family, being, like the clinkstone, superimposed on the secondary strata. Here the blue clinkstone possesses the magnetic virtue in the most eminent degree, but it is also attached to the syenite, as well as to the grey porphyries which are derived from it by the same imperceptible gradation as are the porphyritic varieties of clinkstone from the simple ones.

The magnetic property of a rock of serpentine was remarked by Humboldt some time ago, and I have also found it in this rock in the only situations where I have as yet had an opportunity of examining it, namely at Portsoy, and in the island of Scalpa.* In both these places the magnetic power is considerable, and in some particular spots nearly as great as in the most striking examples among the trap rocks. In hand specimens I have also found that the serpentine of Anglesea, and that known by the name of Egyptian green, exert considerable influence on the needle, so that the property is in all probability generally dispersed among the rocks of this description, as it is among the traps. I may add finally, that I have observed it, but sparingly and feebly, among some of the dark pitchstones, and that in the augite rock which I have formerly described as forming so large a part of the island of Rum; it is as vigorous and common as among the traps with which that rock has so strong an affinity both in mineralogical and geological character.

Such then is the catalogue of the rocks among which I have found the property of disturbing the magnetic needle by the exertion of their own magnetic powers, and it will be seen that they occupy a considerable share of those rocks which constitute the

* To distinguish this Scalpa from other islands of the same name, I must say that it lies at the eastern side of Harris, and is remarkable for its lighthouse.

surface of the earth. Geologists, hereafter perhaps more attentive to this subject, may probably add to this catalogue, or at least augment the number of examples, and add many more to the few localities which I have had opportunities of examining.

To surveyors who are more deeply interested in the fact and its consequences, I shall also look for more extensive and more accurate observations, since the possession of more delicate instruments, and the devotion of time and attention to this particular object, are required to determine the quantity and extent of these influences, as well as their practical effect in producing permanent local variations in the magnetic meridian.

I need scarcely say that an ordinary ships compass is insufficient to detect these variations, unless where they are considerable, as the instrument, either from the rudeness of its workmanship, or the intentional insensibility given it by the maker to render it steady in steering small ships or in navigating through a cross sea, is rarely alive to minute quantities of the disturbing force.

I have attempted on various occasions to discover the positions of the poles of the natural magnets which thus disturb the needle brought within the sphere of their influence. From the observation of Humboldt we are led to imagine that he conceived the rock or mountain which he describes, to have possesed but two poles, and that its effects on the needle could in consequence be easily assigned. This is not impossible, but in all the cases where I have been able to make observations, I have found that the disturbances must have been produced by a number of independent magnets, each rock or fragment being possessed of a meridian of its own, and the disturbances of the needle being in consequence of that, extremely irregular and uncertain. I have already entered into a detail of this fact where I first observed it in Sky, in the

paper to which I have already alluded, and shall not therefore repeat it here. On the extent of their influences I have also spoken in the same place, where I have shown that the needle was sensibly disturbed even at the distance of four feet from the ground. There can be no doubt that influences of this power and extent will produce local variations which if not absolutely permanent, will, by affecting the other better known variations of the needle, introduce errors into those observations which assume for granted a certain local and temporary variation on the evidence of observations made at a distance from the precise point where these additional disturbing forces are in action.

It is already well known to philosophers that the ordinary variations of the needle are not steady, either through small spaces of time, or over a considerable extent of surface, and it is well known that in different parts of Scotland the quantities of the variation are subject at any given time to considerable differences. To this cause are doubtless to be attributed errors in geodesic operations which have occurred even to experienced observers, where these differences were either neglected or perhaps not suspected. The errors in General Roy's Survey of Scotland, appear to have been derived at least in part from this cause. It would be interesting to know how far these local differences depend on the magnetic influences of masses of rock, or merely on the same mysterious cause which produces the ordinary variation, acting in an unequal manner. We must look to future investigations for the solution of this question. In the mean time, while we are sure that such irregularities actually exist, it is plain that much caution is required in the use of surveying instruments, where magnets are concerned either in the observations, or in the adjustment.

In the ordinary operation of maritime surveying by the needle and sights, the errors are often likely to be considerable; more particularly where some of the angles are determined with the instrument placed on shore, mariners having been uninformed with respect to the existence of such disturbing forces. To such causes it is very proble are owing the discrepancies found in charts of new or distant coasts, where the instruments have even been good and the observer practically expert in its use. It is even probable that the charts of the west coast of Scotland, constructed by Mackenzie with abundant leisure and experience in his art, owe many of their very glaring errors to this cause, which on many of these coasts is exceedingly active. Want of care or want of accuracy, as far as this could be obtained by the means which he possessed, cannot be imputed to him, as the soundings, distances, and enumeration of even the most minute sunk rocks, is surprisingly accurate, rendering his work such, that even the most inexperienced pilot may enter these intricate harbours and come to his anchorages with no other guide, as I have abundantly verified on numerous occasions. If, as has been said, the well known map of North Wales constructed by Evans, was also surveyed by the compass, we may perhaps attribute a portion of the errors which it comprises to this neglected cause among others. It is true that the repeated comparison of bearings will afford some correction to inaccuracies of this nature, but a medium of bad observations can never produce a good one.

At any rate where such an instrument is to be used it will always be prudent to erect it on a staff at some distance from the ground, as we shall then at least avoid those disturbances which result from the contact, or very near approach of rocks when it is placed on or near the ground. This addition is easy and of little incumbrance to the operator, and as the compass and

sights is so useful and convenient for ordinary purposes, it will at least render it one degree more correct, although even in this way we shall not avoid those disturbances which arise from the more extensive influence of larger masses of magnetic matter. This caution is equally necessary to the geologist in the taking of geological bearings or angles, since the errors which may arise from its position on the ground are generally considerable, on account of the delicacy of the needle of a pocket compass, and may often be as great or greater than those which proceed from the short radius of the instrument itself, and the consequent difficulty of accurate observation.

In the use of the miner's compass the species of error which I have here noticed is always in danger of becoming serious, from the difficulty of removing the instrument to a sufficient distance from the disturbing forces. Yet even in the narrowest shaft or level an attention to this will enable the miner to take precautions, which, if they cannot entirely remove, will at least diminish in a great degree the probability of serious error.

In adjusting the position of a common theodolite it is evident that one of the sources of error will be sometimes removed, and always diminished, as it rarely happens that the local influences of small masses are felt at the distance at which that instrument is elevated from the ground. Yet I have shewn in the instance of Glamich, that the disturbing power was sensible at four feet from the surface. Such cases are however rare, although the ordinary quantity of the variation will be altered at distances infinitely greater, where the action of mountains or large tracts of magnetic matter is concerned.

In general I may remark that no confidence can be reposed in magnetic angles until the regular action of the needle has been as-

certained by repeated observations on its steadiness at different elevations above the surface, and at different points upon it. It is not a sufficient trial that detached specimens of the rocks in the vicinity exert no action on it, since the variations will often be sensible from the joint action of a considerable mass of polar matter, when small pieces of the same substance produce no effect. The dipping needle would give the most correct information respecting the existence of these local causes of error, but it is an instrument unfortunately too nice and expensive for ordinary purposes. In all cases where such a disturbing force is suspected to be in existence, and where accuracy is necessary, we should not be content until the ground has been examined and the actual variation ascertained by the observation of the magnetic azimuth, wherever it is practicable to procure such an observation. It would however tend still more to the removal of all possible errors arising from this cause, if surveyors were to reject the use of the needle altogether, and depend solely on the back angle; since although every one who lays claim to accuracy will correct the one observation by the other, yet the temptation arising from the facility of using the needle alone, is perhaps too great to be always resisted.*

* After this paper had been prepared for the Society, the voyage of Captain Flinders was published. It gives me great pleasure to find so thorough a confirmation of my observations and suspicions on this subject, in the original remarks of that indefatigable and unfortunate navigator. I was also pleased to see that he had frequently observed the polarity of granite; more frequently I doubt not than it has occurred to me, had he published the details of all his observations. There seems to me also some reason to think, from a remark on which however he does not lay much stress, that he imagined that property to be more conspicuous on the summits of hills than elsewhere.

Since this paper was prepared for the press, there has been published in the Transactions of the Royal Society of Edinburgh a description of the same place, drawn up from the joint observations of Lord Webb Seymour and Professor Playfair. Among other differences, such as may be expected to occur in the observations of different individuals, and which are not subjects for discussion, there are some which call for remark, since they involve questions of nomenclature, the discussion of which may be useful in the present uncertain state of that important preliminary to geological observation. It is much to be desired that all observers should agree in the denomination of those rocks respecting which frequent discordances arise, since without such agreement there can be no prospect of a definite application of terms.

Gneiss is described in that paper as of frequent occurrence. With a few trifling exceptions the most remarkable one of which I have described, I have no where observed any real gneiss among the schistose rocks which form the left ridge of the valley or the great mass of stratified matter. These schistose rocks, as far as my observations go, are clay slate, mica slate, hornblende slate, and quartz rock. Gneiss is a rare rock in Scotland, and is principally to be found in the Long island, in Tirey, Coll, Rona, Iona, and Isla; as well as on the mainland, in Glen Elg, and Morven. I do not consider the rock which is of such frequent occurrence between Blair and Loch Spey, already described in this paper, as gneiss, since although the form is laminar the structure is not foliated: nor have I observed that the gneiss of Scotland any where alternates with mica slate, although it does

with clay slate, nor that it has any immediate connection with granite, much as it resembles it in composition. But in mica slate, as well as in the micaceous quartz rock which occurs in the vicinity of granite, a real gneiss is not unfrequently seen near the points of junction; the schistose rock which in other parts consists of quartz and mica in various proportions, having felspar superadded, and preserving the same parallelism in the disposition of the mica which it possessed before the addition of that ingredient. This change is of various extent, in some cases not reaching many inches beyond the line of contact with the granite, and gradually disappearing even in the lateral progress of the laminæ, while in other instances it occupies a more considerable space. But in no case that I have witnessed is it prolonged through the whole extent of a bed so as to allow us to say that beds of gneiss alternate with or precede the mica slate. I conceive the appearance of gneiss which I have described in Glen Tilt to be of this partial nature, and in all probability owing to similar causes. I would also remark that as quartz rock is evidently recomposed from the ruins of ancient granites, it often contains all the ingredients of that substance. In the extensive remarks which I have made on this rock, as yet so little observed, I have noticed instances in which it has been mistaken for granite. In the same way it may be mistaken for gneiss, since with a stratified structure it may contain all the ingredients of that substance. Nay, even the mica may be disposed in the same parallel form in the triple compound as it is in the more ordinary mixtures of quartz and mica. Even here however an experienced eye may detect differences which words are inadequate to define, and the true connections and nature of the rock may be known, by tracing its connections with, and gradation into, the

more characteristic beds of quartz rock with which it is associated.

The next remark I shall make is on the term syenite, which in the paper alluded to is applied to that rock which I have called granite. The difference here is merely a question of expediency, and I shall content myself, in addition to what I have already said on that subject, with a brief statement of my reasons, as I shall have occasion to discuss this point at some length in giving an account of the Western islands.

Werner has described syenite as an overlying formation, and incumbent on granite. With a rock of these characters I have no acquaintance, and his description is therefore unintelligible to me in a practical view.

But there are in Scotland (and elsewhere) two compound rocks formed of the ingredients described in his definition, namely, quartz, felspar, and hornblende, but occupying two positions, in a geological view most distinct, and neither of them agreeing with that which he has assigned for his syenite. That to which I have thought it expedient to limit the term, is incumbent upon the secondary strata and at the same time interferes with them in the same way that certain varieties of trap and porphyry, with which it is intimately connected, are known to do; examples of this are to be found in many of the Western islands. It is therefore not only posterior to these strata and distinct from the syenite of Werner in its geological relations, but it differs from it in composition, inasmuch as it does not contain mica, unless, as some also of the traps do, accidentally.

The other rock which agrees with the mineralogical definition of syenite, is found connected with granite and consequently subjacent to the most ancient stratified rocks. I have attempted to shew

in this paper, that it passes into granite, and is associated with it in an intimate manner, having no further the appearance of stratification or of an overlying character than granite has, and bearing precisely the same relation to the stratified rocks which that does. In aspect it has generally a considerable resemblance to granite; often indeed it cannot be distinguished without a careful inspection, while the syenite which lies above the secondary rocks rarely has a granitic aspect. This variety frequently contains mica as well as hornblende, and it is indeed not rare to find the former ingredient far exceeding the latter. There appears therefore a sufficient mineralogical distinction between these two rocks to justify us in distinguishing them by two names, without infringing the rule which I have suggested on another occasion,* that we were not at liberty to vary our principles of nomenclature, by drawing them sometimes from mineralogical character, and sometimes from geological position. But for this purpose it is necessary that the whole of any mass of rock should be considered together, and that its mineralogical character should be defined by its prevailing, not by its occasional composition. Whatever more experienced geologists may determine on this question, it is indubitably necessary that the confusion which I have here pointed out should be removed by some expedient, and I shall gladly conform to any better suggestion; but it is too plain that the indiscriminate application of the term syenite to two rocks so essentially different in connections, would tend to produce a most incurable confusion in geological description.

The last remark which I shall make on the apparent discrepancy between my observations and those of the philosophers abovementioned, is also little else than a question of nomenclature. It

* Vide Miscellaneous Paper, Vol. II. of Geological Transactions.

consists in the use of the term greenstone, which has been applied by them to some of the dark varieties of the syenitic granite. It has appeared to me, as I have remarked in the body of the paper, that these varieties of syenitic granite were distinguishable from true greenstone by the presence of quartz, and that however minute their texture, and apparently uniform the white ingredient, it always contained that mineral in conspicuous proportion, while in greenstone, a common member of the trap family, it was rarely present, and might, when present, be considered as accidental. If I have been mistaken in this observation, I shall consider it unfortunate that no criterion of a mineralogical nature can be found to distinguish these rocks, if indeed the presence of the occasional minerals, mica, epidote, or sphene, minerals in general of a more ancient origin, cannot lend us some assistance. It is so necessary to prevent rocks distinct in their geological relations from being confounded, that the terms which are assigned to them ought if possible to be equally distinct, since the mere effect of terms, as we all experience, has in every science a powerful effect in misleading or influencing our judgments. If there really be no such distinction as I have here thought probable between certain syenitic granites and the greenstones of the trap family, it will then be necessary to have recourse to the same expedient as we use in distinguishing the limestones, the addition of the terms, primary, and secondary; an expedient however, which in this case it would be desirable to avoid, since many geologists are inclined already to distinguish by the addition of these very terms the real trap rocks which are found connected with primary or with secondary strata.

IX. *Sketch of the Geology of the South-Western Part of Somersetshire.*

By LEONARD HORNER, Esq. F.R.S.

MEMBER OF THE GEOLOGICAL SOCIETY.

[Read March 3, 1815.]

§ 1. I BEG leave to offer to the Society an account of some observations on the mineralogy of that part of Somersetshire which lies on the Bristol Channel westward of the river Parret. The shortness of my stay in the country prevented me from conducting my examination with that minuteness of detail which an accurate survey should possess, but I trust that with the assistance of the accompanying map* and the series of specimens which I have deposited in the museum of the Society, the following notes will be sufficiently distinct to afford a general view of the geological structure of that part of England. I have distinguished in the map, by means of different colours, the situation which the several rocks occupy, and although, from unavoidable sources of error, the boundaries of each can only be considered as approximations to the truth, yet I do not conceive that the inaccuracy in that respect is so great as to affect any geological deductions.

§ 2. In the western part of Somersetshire, and partly within the adjoining county of Devon, there is a large district of high land, the greater part wild and uncultivated, extending about 30 miles from east to west, and about 16 miles between north and

* Pl. 23.

south, the highest and wildest part being known by the name of Exmoor Forest. In appearance and structure it is very analogous to a great part of Devonshire and Cornwall, and may be considered as the termination of those schistose rocks which prevail so much in these counties. It is divided into several ranges of hills, distinguished by particular names, the most conspicuous of which are Dunkery beacon, Brendon hill, Croydon hill, Grabbist hill, North hill, and the Quantock hills. The longitudinal direction of these is, with the exception of the Quantock hills, nearly east and west; there are numerous lateral branches from each central ridge, forming small steep vallies, or gullies, which terminate in the great vallies that divide, and are parallel to the principal ranges. These gullies, called Combes in the country, when richly wooded, form some of the most striking features of the beautiful scenery for which this coast is so celebrated. The Quantock hills, although cut off from the main body of this mountainous tract by a wide cultivated valley, may, in a geological point of view, be considered as strictly belonging to it, for the range itself and the intervening valley are formed of the same rocks as the country to the westward. This apparent insulation, and the peculiar beauty of the range, mark them as a prominent feature in the country; they are no less remarkable from the varied scenery they afford, and the magnificent prospect that is seen from their summit. The name is generally applied in the country, as it is in the Ordnance map, to a range of about eight miles in extent from north-west to south-east, and which is in fact the highest and most conspicuous part. From the south eastern extremity, the mass is divided into several distinct ridges, all composed of the same materials as the Quantock hills strictly so called, and which spread out in the form of a fan, having one extremity at North Petherton, and the other at West Monckton,

with a gradual fall to the alluvial land on the banks of the rivers Parret and Tone. On the western side of the Quantock hills the descent is very rapid into the valley; on the eastern side it is in general much less so, and a great many lateral branches stretch out at right angles to the range, shooting off, however, considerably below the summit. These sometimes terminate at a very short distance from the central ridge with an abrupt slope, at other times they descend very gradually almost to the Parret, shewing occasionally at their termination their identity in composition with the central mass.

The whole of the mountainous country I have mentioned has a smooth undulating and rounded outline, no where rugged or presenting any cliffs or precipitous faces, except on the sea shore, where sections have been formed probably by the action of the tides. The whole country is so covered by vegetation, either in the form of heath and turf on the high land, or of the more luxuriant productions of the vallies, that very few opportunities occur in the interior of ascertaining the nature of the rock on which the soil rests; but the cliffs on the sea shore afford such an ample field for studying the mineralogical structure of the country, that the scattered observations in quarries, may be more strongly relied on and more easily connected.

§ 3. From the Parret to Barnstaple Bay there is no river of any magnitude: the great watershed is to the south, and the Ex, one of the most considerable of those rivers which fall into the English Channel, rises in Exmoor Forest. The southern shore of this part of the Bristol Channel is very steep, the sea in many parts not leaving the cliffs in the lowest tides. From Minehead Point westward, the charts give 8, 9, and 10 fathoms water close in with the shore. Eastward of that point the coast is more flat, and towards the mouth of

the Parret the distance between high and low water mark is in some places above two miles. From the town of Minehead there is a tract of low marsh land, extending eastward about four miles along the coast, and about a mile in breadth in most places from the sea to the base of the hills. Were it not for a bank of pebbles which the sea has thrown up on the beach, this land would be overflowed every tide; and this even now generally occurs when the tides are unusually high. A similar tract of marsh land occurs in Porlock Bay, which is equally protected by a very great shingle bank, divided into three terraces rising the one above the other, the highest part of the bank being not less than forty feet above low water mark. The pebbles, which all along the shore are of the same materials as the cliffs in the open part of Porlock Bay, are of various sizes, but they are in general flattened spheroids of about six inches in diameter; as they approach the cliffs at Hurstone Point, they become gradually less, and close to the cliffs, they are of the shape and size of a pigeon's egg, and nearly all alike.

Dunkery beacon is stated in the report of the Ordnance Trigonometrical Survey to be 1668 feet above the level of the sea, and, with the exception of Cawsand beacon, in the northern part of Dartmoor Forest, which is stated in the same report to be 1792 feet, is I believe, the highest land in the West of England.

Grabbist hill I found, by barometrical measurement, to be 906 feet above low water mark. The highest part of the ridge is immediately above the village of Wotton Courtney. I made use of Sir Henry Englefield's mountain barometer, and I have calculated the heights by the formula he gives.

North hill above Bratton, which appeared to me the highest part of that ridge, I found to be 824 feet above low water mark,

The western extremity, which I did not measure, judging from its appearance at a distance, can be very little less than this height.

The Quantock hills when viewed from a distance, present a gently undulating outline, which rises in three places into a more prominent elevation, the most northern being called Doucebury,* the central height Will's Neck, and the most southern Cothelstone Lodge, from which last point the range diverges, as has been already noticed. Will's Neck is the highest of the three, and was measured at the time of the Trigonometrical Survey, and found to be 1270 feet above low water. It is called in the Survey the Bagborough station, being immediately above the village of that name. Doucebury I found by the barometer to be 1022 feet, and Cothelstone Lodge 1060 feet above low water mark; but as both these measurements were made under very unfavourable circumstances, they are not to be relied on. Doucebury must be considerably higher than I found it to be; the measurement of Cothelstone Lodge is probably not very far from the truth, judging in both cases from the comparison between the three heights when seen at a distance.

§ 4. The whole of the mountainous part of this district is formed of a series of rocks differing very considerably in mineralogical characters, but which the repeated alternations of the several varieties, and the insensible gradations that may frequently be traced of one into another connect into one common *formation*. A great proportion of these have the structure of sandstones, the component parts varying in size from that of mustard seed to such a degree of fineness, that the particles can with difficulty be discerned. Quartz and clay are the essential component parts of all the varieties, but in different proportions. The quartz in some

* This is the name by which it is universally known in the country, but it is called *Danesborough* in the Ordnance map.

instances prevails to the entire exclusion of any other ingredient, forming a granular quartz rock: it is more abundant in the aggregates of a coarse grain, clay being the chief ingredient in those of a close and fissile texture. They have all an internal stratified structure, which is less apparent in those of a coarse grain, (and in a cabinet specimen scarcely discernible) but which becomes gradually more distinct as the texture becomes finer, and at last the rock graduates into a fine grained slate, divisible into laminæ as thin as paper, and having the smooth silky feel and shining surface of the clay slate of a primary country. Alternations of the fined grained slaty varieties with those of the coarsest structure in many successive strata and without any regularity of position, are of constant occurrence, and frequently without any gradation from one structure into the other.* In some instances portions of slate are contained in the coarse grained varieties. Scales of mica are frequent, and they all contain oxide of iron in greater or less proportion, and to the different states of this oxide their various colours are, no doubt, to be ascribed. The prevailing colours are reddish brown and greenish grey, and there are many intermediate shades and mixtures of these colours. Some of the slaty varieties are of a purplish hue, and this is occasionally spotted with green. Of the specimens I collected, those of a coarse grain and of a dark reddish brown colour, do not effervesce with acids; those of a pale reddish brown colour, and of a greenish grey colour, all effervesce, and some of them briskly. None of the varieties of slate shew any signs of effervescence. The magnet was not affected by any one of the series. I did not discover a trace of any organic body in either

* Similar alternations of clay slate with grauwacke have been observed at Crinan and at Aberfoyle, by Dr. Mac Culloch. (Transactions of the Geological Society, Vol. III. p. 441, 447.) and by Mr. Jameson in the Pentland Hills. (Memoirs of the Wernerian Natural History Society, Vol. II. Part I. p. 184.)

variety, but in many places great beds of limestone full of madrepores, are contained in the slate, the limestone and slate towards the external part of the beds being interstratified. Veins of quartz, which are often of great magnitude, are of constant occurrence, being sometimes accompanied by calcareous spar and ferriferous carbonate of lime; veins of sulphate of barytes are not uncommon. Thin layers, composed of quartz, chlorite, and ferriferous carbonate of lime, are often interposed between the strata of slate, and pyrites is sometimes disseminated through the mass of the rock. Copper, in the state of sulphuret and of malachite, and veins of hematite, are frequently found, and nests of copper ore of considerable magnitude have been found in the subordinate beds of limestone.

Those who are acquainted with the geology of Devonshire and Cornwall will recognize in these characters a great similarity between the rocks which I have been describing, and those which form so large a portion of the western counties, and which have of late been designated by several mineralogists by the term *grauwacke*. I am fully aware of the unwarrantable extension of this name, and of the great want of precision which has been the consequence of applying it without pointing out the mineralogical structure of the compound; but I feel in common with many others the difficulty of finding a less objectionable term by which the series of rocks in question may be distinguished, when it is necessary to speak of them collectively. As the word by itself conveys no theory, and as these rocks have a closer connection with that class to which the term was originally applied than with any other, I shall call the series of rocks which I have described, a *grauwacke formation*, hoping that the description I have given will, in some degree, remove that want of precision which is the

chief objection to the word. To those however who may give to it the theoretical meaning which this word implies in the Wernerian system, I must again point out the alternations of quartz rock, and of a clay slate, with beds of limestone full of organic remains. The clay slate cannot be distinguished from that of a primitive country.

§ 5. A reference to the accompanying map will serve better than any description to shew the extent of country occupied by this formation: it remains for me to point out some of those circumstances connected with it which appear to be worthy of more particular notice.

The north hill which extends along the shore from Minehead to Porlock, forming a very bold and precipitous coast, affords the best opportunity of studying this grauwacke formation. At Greenaley point, about a mile westward of Minehead, there are very lofty sections where the alternations of the different varieties may be distinguished, and where there are also very good examples of those curvatures, which, in this formation, are of such frequent occurrence. Strata that run for some distance in a horizontal line suddenly turn up into a vertical position, at other times they assume the form of an arch or a succession of great curves. It is hardly necessary to say that these rocks could not have been deposited in the forms they now exhibit, and it is pretty evident that the flexures must have taken place while the rock was in a plastic state, for there is no fracture at the bendings, nor any interruption to the continuity of the mass. Similar curvatures are to be seen at Hurstone point, the western extremity of North hill. These appearances are so well known that drawings of them are unnecessary: they are very analogous to those observed by Mr. Conybeare in the same rocks on this coast, some miles westward, and repre-

sented in the 33d and 34th Plates of the 2d. Volume of the Society's Transactions.

§ 6. In every part of the district where the slaty varieties prevail, the ends of the inclined strata as they rise to the surface become either vertical or are very much twisted. Here however the contortions appear to have taken place after the induration of the stone, for they are not in the form of curves, but are in general a succession of sharp angular twistings, with a fracture at every angle. The strata in general as they approach the surface are also very much traversed by those imperceptible cracks which make the rock, as soon as it is moved from its bed, break down into polygonal fragments of various dimensions. Hence are probably derived those loose fragments which are to be found under the surface soil all over the district where this formation occurs, and even at the summits of the highest hills. In the ravines formed by the streams in the lower parts of Dunkery beacon, there are sections of some yards in depth where nothing is seen but these fragments, imbedded in a loose red sandy soil, which is doubtless produced from the decomposition of the fragments themselves. The angular shape of the fragments is an additional proof that they have been produced on the spot, and that they are not materials transported from a distance. The most remarkable instances of these angular contortions are to be noticed in the lanes between the village of Enmore and West Monckton, and the other roads which cross the south-eastern ridges of the Quantock hills. I may particularly point out the neighbourhood of Adsborough, and the lane leading to Tarr near Kingston, where the ends of the strata of slate are covered by horizontal beds of red argillaceous sandstone and of conglomerate.

§ 7. In a country covered by vegetation, and where the rock is

so liable to partial irregularities, it is exceedingly difficult to form any general conclusions as to the bearing and dip of the strata. Every geologist must have observed that the external shape of a hill is not always a certain guide in determining the bearing of the strata that compose it, and that in many places other causes must have operated in producing the external forms which the earth now exhibits. I believe however that the general bearing of the strata in question may be stated to be between east and west, and that the dip is more generally to the south than to the north.

§ 8. In the ridge which terminates at North Petherton, there are at Binfords some very large quarries where the gradation of one variety of rock into another may be seen. In the lower part of one of the beds there is an accumulation of rounded masses of an oblong shape, varying in size from a few inches to several feet, in the direction of what may be termed their longest diameter. Their internal structure is often identical with the adjoining strata of grauwacke, but they more frequently consist of a succession of thin concentric layers, these layers being of the same substance with the strata, but separated from each other by a thin coating of oxide of iron, having the shining lustre of hematite. The smaller of these masses more nearly resemble a large mytilus than any other shape to which I can compare them, and the larger of them preserve nearly the same form. They appear to have been consolidated while the rock in which they are imbedded was in a soft state, for the surface of the bed on which they rest is covered with the moulds of those that have been removed.

§ 9. Near Ely Green in the side of a combe called Dibbles, towards the summit of the Quantock hills, I observed a variety of slate differing considerably in appearance from any I met with in the district except in one other spot. It is of a bluish green

colour, apparently derived from chlorite, with purplish stains and including small spherical masses of a white earthy texture, which give to the mass an amygdaloidal structure: it may be considered as a variety of argillaceous slate, and as it occurs in strata conformable with the usual varieties of the grauwacke formation, it belongs I have no doubt to the same class: it is found to be very useful as a fire stone. The other place where I found a slate very similar to this was in the neighbourhood of Cheddon Fitz-Paine.

§ 10. In passing through the village just named, I observed in the street a small block of stone differing in appearance from any I had found previously, and upon examination I found it to be granite, a rock I had searched for before without success, and indeed this is the only place where I saw an unstratified rock in the whole district, the porphyry and greenstone which accompany the grauwacke formation in Devonshire being wholly wanting here. On inquiry I found that this granite, called by the country people *Pottle Stone*, came from an old quarry not far distant in the grounds of Hestercombe, belonging to T. Warre, Esq. My informer brought out of his house a whetstone which he said came from another quarry close by the *Pottle Stone*. It was a greenish compact stone, very like some hornstones or some of those close-grained siliceo-argillaceous compounds which it is very difficult to name. On going to the quarry, which is almost entirely overgrown with brushwood, I found the granite *in situ*: it is small grained, and consists of dull flesh-coloured felspar, with green mica, and a small quantity of quartz. It occurs in the lower part of the hill and occupies a very limited extent. Immediately adjoining is the spot where the whetstones are got. Here I found regular strata of slate similar to that occurring in many parts of

this district, inclined at a considerable angle and rising towards a mass of the granite which appears in the form of a wall a few feet above the ground. Within a few yards of the granite the inclination of the strata is about 35°, but as it approaches nearer to it the angle increases to 63°, and the texture of the stone becomes much more compact; the actual junction of the two rocks is, as is usually the case, very indistinct, the stratification of the slate being very much disturbed and broken: but I was informed that the best whetstones are got nearest the granite, and I found the most indurated pieces in that situation. Being desirous of seeing the actual contact, I obtained permission from Mr. Warre to clear away the ground across the line of junction: and although the quantity of brushwood, and thick covering of soil, and a very unfavourable state of the weather prevented me from making so complete an examination as I wished, I so far effected my purpose as to find the junction. The granite as it approaches the slate becomes much finer grained than before, and at the contact there is an indistinct blending of the two, and as far as I can judge from the very imperfect specimens I could obtain, there is an appearance of fragments of the slate united by a granitic cement. All the circumstances appear to favour the supposition of this being a vein of granite, but the evidence I have to offer is too scanty to enable me to speak with confidence on the subject.

§ 11. Some years ago a shaft was sunk in one of the branches of Grabbist hill at Stanton, above the village of Alcombe, in consequence of some indications of copper in the rock there, but the quantity of ore found was so small that the workings were very soon given up. I found among the rubbish some pieces of green carbonate of copper with grey copper. Similar trials with no better success were made at Perry near the northern extremity of

the Quantock hills. I found there, among the rubbish, specimens of malachite and of brownish-black sulphuret of copper.

I received from Thomas Poole, Esq. of Nether Stowey, a specimen of an exceedingly hard and compact iron ore which had been found in the Quantock hills, but in what place he could not inform me. It is an oxide of an iron-grey colour and semi-metallic lustre, with a sharp splintery fracture, and so hard as to scratch glass easily. Its specific gravity I found to be 5.244, which with its other characters brings it nearer the *fer oligiste* of Haüy than any other variety of ore. The occurrence of so rich an ore in a large quantity, would be a very valuable discovery.

§ 12. In several parts of this district there are found, as I have already stated, very considerable beds of limestone which are contained in the slate. Their occurrence in detached spots, and their appearance in the quarries where they are most extensively wrought, seem to point out that they are not regular strata conformable with those of the slate above and below them. Flattened spheroidal masses of the same kind of limestone are frequently found, completely enveloped by the slate, and very similar to the balls of clay-iron-stone in slate clay, but thinning away at the edges much more than those do. I conceive that the great masses of limestone occur in the same way: they have an irregular bedded structure, and very often layers of slate, often of considerable thickness, are interposed between the beds; but although the positions of the quarries along the eastern side of the Quantock hills appear in a continuous line on the map, the great variations in the bearing and dip of the strata of those quarries renders it extremely improbable that the limestone of each, although very similar, are parts of regular strata. These beds of limestone appear to be confined to the places where the slaty varieties of grau-

wacke formation prevail; I shall now point out some of the most extensive quarries where they are worked.

§ 13. At Allercot, about four miles south of Minehead on the road to Dulverton, the principal bed of limestone is 30 feet thick. It is of a bluish grey colour, variegated with red, of a crystalline structure, and full of small laminæ of calcareous spar disseminated in detached spots through the mass, which are most probably the remains of organized bodies. Besides this great bed, there are several others of less thickness contained in the slate, and the thinner beds are of an iron-grey colour. The slate is one of those fine grained varieties which approach very nearly in appearance to the clay slate of a primary country; it is very much contorted, and the curvatures are often so small as to be seen in a cabinet specimen. Is is very much traversed by veins of quartz. I was informed by the workmen at Allercot that there are quarries of a similar kind of limestone at Westcot, Treborough and Leigh. At Treborough a very excellent roofing slate is obtained.

§ 14. At Doddington, Friern farm, and Ely green, on the eastern side of the Quantock hills, the quarries are very extensive. In those of Friern farm I found some of the beds to be a very close grained crystalline limestone without the slightest appearance of any organic remains; but upon a close examination of the stone when broken in different directions, and particularly at those places where it is bruised by the stroke of the hammer, I found many parts of the bed to be almost entirely composed of a madrepore. Towards the exterior, madrepores are very distinctly seen, and in some of the beds the stone is full of circular bodies composed of large crystalline plates of calcareous spar, which I have little doubt are entrochi, but I did not discover a shell any of description.

§ 15. In the quarries at Great Holwell there may be seen on a small scale that occurrence of caverns so frequent in limestone. They vary in width from half a foot to five feet, and their height varies with the thickness of the beds. In some places they may be seen to close, but in general their depth was beyond what I could ascertain. Their sides although uneven by the irregular projections of the rock have all a smooth rounded surface, as if worn by attrition, but this seems to be owing to an incrustation of calcareous spar which hangs down in many places in large stalactites, a process that is evidently going on at the present time in several of these caverns. That the caverns have not been produced by any rents that might have occurred after the consolidation of the strata, is evident from their being confined to the limestone and not extending through the intervening slate.

§ 16. Nests of copper are very frequently found in this limestone. I observed in several places small nodules of the green carbonate enveloped by brown ochreous earth. At Doddington a very large quantity was found some years ago. A loose friable quartzose sandstone, which I shall afterwards notice, was found to contain so much copper ore that a mine was sunk in it. In order to drain the works which were situated upon the rise of the hill, a shaft was sunk for the purpose of driving a level from north to south up to the workings, expecting at the same time to cut across any veins of metal that might exist there, as they are generally supposed in this part of the country to run east and west. They had proceeded a very short way in driving this level when they came upon a black slaty limestone, and immediately afterwards they found a large nest of copper ore, consisting of the green carbonate, and yellow sulphuret. The workings in the sandstone were immediately given up; they

did not continue driving the level, but worked in the limestone on all sides. The mine has however been abandoned, as the produce was not sufficient to bear the expence of an engine to drain off the water.*

§ 17. I found specimens of the black slaty limestone at the mouth of the pit, and I afterwards observed the same stone in the limestone quarry near Ely green interposed between the beds of limestone. It is of a coal black colour, but becomes white when heated: dissolved in muriatic acid it leaves a black powder, and this powder when heated is partly dissipated, and what remains is a white earth. The limestone appears therefore to owe its black colour to carbonaceous matter.

Besides the quarries I have named there are several others, but as they present no appearances different from those I have already described, it is not necessary to do more than mark their occurrence on the map.†

§ 18. About a furlong eastward of Halsey cross, in a quarry where stones are obtained for mending the roads, I found strata of the coarse grained and slaty varieties of the grauwacke formation, alternating with a calcareous rock different from any other I had seen in this district. Its colour is in general reddish brown, very similar to the strata that alternate with it, but the calcareous strata are not all alike. In none of them are there any traces of organic remains, unless indeed some detached crystalline laminæ may be considered as indications of them. The principal varieties are

* I received this account of the Doddington mine from my friend Thomas Poole, Esq. of Nether Stowey.

† The position of many of those quarries has been pointed out to me by my friend the Rev. John Poole of Enmore, to whom I am indebted for much valuable assistance in the prosecution of this inquiry.

1. A crystalline limestone which burns to a white lime mixed with brown spots, falling very readily to powder. 100 grains dissolved in dilute acid left 7 grains of residuum, which consisted of about 4 grains of oxide of iron, the remainder being silica.
2. The preceding variety mixed with a considerable quantity of quartz, and of yellow calcareous spar. This latter substance occurs also in veins and probably pervades all the calcareous strata. A piece of that stone when thrown into dilute acid leaves a fragment which does not fall into powder.
3. This variety is intermixed with a smooth slaty substance with an unctuous feel, which is probably talcose slate: it leaves a considerable quantity of large grains of quartz when thrown into dilute acid.

None of these calcareous strata are used for any other purpose than to mend the roads, and they do not seem to be known as limestones, most probably because there is a much better limestone so near at hand. The first variety would yield a very good lime, if reliance for that purpose can be placed on my minute experiments; a trial on the large scale might very easily be made in one of the neighbouring lime kilns. The principal calcareous stratum is five feet thick.

Immediately behind the village of Bagborough I found a calcareous stratum occurring in the same way as those at Halsey cross.

§ 19. My observations were principally confined within the limits I have already mentioned, but having had an opportunity of making a cursory examination of the country between Porlock and Ilfracombe, and as the rocks occurring in that part of the country are connected with those I have been describing, I shall briefly state the few notes I made. My route was from Porlock, by Culbone,

Withycombe farm and Countesbury to Linton, and from thence through the Valley of Rocks by Slattenslade, Trentishoe, Combe Martin and Berry Narbor to Ilfracombe. A very great part of this country is entirely concealed by vegetation, but wherever the rock is exposed I found some variety of the grauwacke formation identical with those I had left behind. In that part of the road which is eastward of Linton, the coarser grained varieties are most frequent, but westward of that place the slaty varieties predominate, very often resembling some kinds of iron-grey clay-slate found in primary countries. Towards Ilfracombe this appearance becomes still more decided, and in a cabinet specimen it would be impossible to tell the difference. But beds of limestone with very decided indications of organic remains contained in this slate, show that it is of secondary formation, and at the same time afford a useful lesson of the inadequacy of mineralogical characters alone to determine the geological nature of a rock. These limestone beds are found between Berry Narbor and Hele; their resemblance to those I have described in the former part of this paper both in internal composition and in the accompanying slate, leave no doubt of their belonging to the same class. When struck with a hammer it emits a slight bituminous smell, a circumstance which I did not observe in the limestone of the other places I have mentioned, and it is traversed by very large veins of a transparent and very beautiful calcareous spar.

§ 20. Throughout the whole district described in this paper I found the grauwacke formation surrounded either by a conglomerate, or by a red sandstone, sometimes tolerably compact, but more frequently of a friable texture. These conglomerates and sandstones assume very various appearances, but under every form of aggregation the same materials may be traced. Where the

component parts are large, as in the conglomerates, the nodules consist of some of the varieties of rock that compose the grauwacke formation; and in many places there are nodules of a limestone very similar to that of the subordinate beds in the same series. These *derivative* rocks under one form or another are found in all the intervening valleys, and the great valley on the western side of the Quantock hills is wholly composed of them. They are not however confined to the vallies, but are sometimes found on the sides of the hills at a very considerable elevation. It would have been a fruitless task to have attempted to distinguish in the map each particular form of aggregation, more especially as I did not discover any uniformity in their relative positions. I have thought it better to class the whole under one head and to represent them as such by one colour. It will be necessary however to point out in detail some of the most remarkable instances.

§ 21. In the eastern and highest part of the valley in which the village of Porlock is situated, there is found at Tivington, Huntsgate and Holt farm, a conglomerate composed of thin fragments of a coarse grained slate seldom exceeding an inch in size, with pieces of quartz, cemented by white calcareous spar. The surfaces of the fragments are rounded by attrition, and are coated with reddish brown oxide of iron, which has in many places the metallic lustre of hematite. The fragments are in some places so small that the rock has the appearance of a sandstone. It occurs in thick beds which are often inclined at a considerable angle, but not conformable with the slope of the hill in the lower part of which the conglomerate is found. The smaller grained rock frequently alternates with the coarse conglomerate: at Tivington the latter variety prevails, but at Huntsgate that resembling a sandstone forms the thickest beds. Both varieties are very much traversed by veins of calcareous

spar. At Holt farm there is a vein nearly 18 feet thick, consisting of several layers so distinct that I at first conceived the mass to be a series of strata, but upon further examination I found that it was inclined at right angles to the dip of the beds of conglomerate. It is stratified not only on the great scale, but also in the internal structure, which consists of a succession of layers, having in many places a waved appearance similar to that seen in sections of recent calcareous depositions. Part of this vein consists of a mixture of white, red, and honey-yellow calcareous spar, resembling in some places cellular quartz. The quantity of calcareous matter in this conglomerate is so great that it is quarried for the purpose of obtaining lime from it. But at Holt farm, the great size of the vein renders it unnecessary for them to use the less pure conglomerate.

§ 22. In the lane leading from the town of Minehead to the church, which is situated near the eastern termination of North hill, the rock has been cut through to a considerable depth. At the first part of the ascent it is a friable red sandstone distinctly stratified, and dipping north-east by north about 15° as it were into the hill. It is almost entirely siliceous, and contains no calcareous matter, nor are there any of those grey patches which generally accompany the marly red sandstone to be afterwards described. It appears to rest upon a conglomerate, that rock just appearing above ground. Continuing to ascend, this red sandstone after a short way is suddenly broken off, and is succeeded by a conglomerate which continues during the remainder of the ascent, till it meets the grauwacke formation immediately above the church: unfortunately the actual contact is not exposed. This conglomerate consists of rounded fragments of rocks identical with those found in the grauwacke formation, but without any limestone. In different parts of it there are patches of the same red sandstone that occurs in the first part of

the ascent, varying from a few inches to several fathoms in extent, and having in general a stratified structure.

§ 23. Near the village of Alcombe, and at the foot of one of the lateral branches of Grabbist hill, there is found a conglomerate differing considerably from either of those already described. It occupies a very small space superficially, probably not more than a square furlong, but it is found in very thick beds. It is composed of rounded fragments of the coarser quartzose varieties of the grauwacke series, of limestone and of quartz, united by a calcareo-argillaceous cement of a reddish brown colour. The limestone is in general grey with a reddish tinge, of a crystalline texture, with laminæ of calcareous spar scattered through it, and frequently containing carbonate and sulphuret of copper; characters sufficient to identify it with the subordinate beds of the grauwacke formation. In one or two instances I found it containing chert. In some parts of the conglomerate the cement is very much mixed with white and flesh coloured sulphate of barytes in crystalline plates, and with green carbonate of copper. It is also traversed by veins of calcareous spar, and contains cavities lined with crystals of the same substance. The fragments are of different sizes; some of them are as large as a man's head. The conglomerate is covered by a loosely aggregated quartzose sandstone, varying in colour from reddish white to brownish red, and often containing much calcareous matter. Sometimes there are fragments of the same varieties of grauwacke that occur in the conglomerate, found in those parts of the sandstone that are contiguous to it; and it is also mixed in some places with green carbonate of copper and with sulphate of barytes. In the upper part of the conglomerate there are rounded fragments of a sandstone mixed with carbonate of copper nearly identical with that of the beds lying over the conglomerate. This sandstone is about 5 or 6

feet in thickness, and dips northward about 18°. The signs of stratification are not very distinct in the conglomerate, but the beds appear to dip at the same angle and towards the same point as the superficial sandstone. This conglomerate is called *Popple* rock (Pebble?) by the quarriers, and is worked on account of the nodules of limestone, which are picked out and made into lime.

§ 24. Opposite Bickham farm near Timberscombe, and at the foot of the hill which may be considered the eastern termination of Dunkery beacon, another modification of the conglomerate occurs. It is composed of large irregularly-shaped flat masses of limestone imbedded in a pale green sandy clay. Between these masses there is interposed a conglomerate of smaller sized fragments, very analogous to that found at Tivington, and the whole series is covered by a friable red marly sandstone. The limestone is similar to that found in the conglomerate at Alcombe. The lower part of the valley on the south side of Grabbist hill is chiefly meadow land, but in some places where the ground is broken, as in the road near Wotton Courtney, and in the road from Timberscombe to Minehead, I observed a red marly sandstone with grey patches containing thin strata of a small sized very compact breccia composed of fragments of a white indurated clay, united by a cement of clay mixed with calcareous matter, and here and there small cavities in it lined with calcareous spar. This compound I did not find in any other part of the district.

§ 25. The valley which separates the Quantock hills from the mountainous country to the west does not present a uniformly even surface: there is along its whole extent a succession of low hills having a longitudinal direction parallel to that of the valley. There are two ranges of these hills, but the most conspicuous are on the side of the Quantock hills. The whole of this valley is occupied

by the derivative rocks I have been describing, and all the different modifications to be found in the district occur in this valley, and the whole of the low hills are composed of them. In the bottom of the valley there is a considerable tract of loose sand. On leaving the grauwacke series near Dunster, we find at Carhampton a low hill composed of a red argillaceous sandstone, and proceeding eastward towards Williton, either that sandstone, or a sandstone containing rounded fragments of the grauwacke formation appears in all those places where the ground is broken. At Tarr, Tor Weston, and Vellow, the same conglomerate (or pebble rock) that I have described at Alcombe, again appears. At Tor Weston the quarries are situated near the top of a small detached hill, the conglomerate forming beds of great magnitude. At Vellow there are sections of it above 50 feet in height, and it rests here upon a bed of red clay. There are distinct parallel lines which divide it into thick beds, dipping northward about 10°. It contains here more fragments of limestone than it does at Alcombe, and I found between the pebbles in some places, small nests of hematite. It is covered as at Alcombe by a sandstone, but of a different variety, being of a deep reddish colour and full of fragments of grauwacke, and without any appearance of copper or of sulphate of barytes. The same sandstone may be seen in different places between Williton and Vellow, particularly near the village of Sampford Brett. A little to the west of Williton church, there is a reddish white sandstone, much harder than any other I met with in this district. It occurs at the eastern termination of the same ridge, on the west side of which the quarries of conglomerate at Tarr are situated, and I think that it is very probably only a variety of that sandstone which covers the conglomerate in other places. If it is stratified the lines of separation are very indistinct. There are many perpendicular fissures in it; part of

which are filled with a pulverulent carbonate of lime. It is very durable when used for building, and Watchet Pier has been repaired with it. The *Popple rock* of Vellow extends as far as Yard farm, and I observed it in the road near Quark-hill farm on the eastern side of the brook.

§ 26. At Lawford farm near Crowcombe there are some large quarries where different varieties of the derivative rocks may be seen. The conglomerate, besides its usual component parts, is accompanied by patches of a green sandy clay, similar to that in the quarries near Timberscombe, and I may remark here that these green patches are prevalent in almost all the forms of conglomerate on the south and south-east slopes of the Quantock hills.

The conglomerate at Lawford farm is covered by several beds of red sandstone, which are in general separated from each other by a layer of rounded fragments of grauwacke mixed with red earth. There are also several beds of conglomerate which are separated by beds of sandstone, lying nearly horizontal: some of the sandstone beds give more lime than any other in the quarry. This series of beds extends for some distance towards Lydeard St. Lawrence by Crowcombe Heathfield, and is succeeded near that town by red sand.

§ 27. A road is carried along the side of the Quantock hills from Crowcombe to Bagborough by Triscombe. The derivative rocks prevail all along this road, although it is at a very considerable elevation: this is the greatest height at which I found them, except in one place on the eastern slope of the Quantock hills, *and near the summit of the range*, at Quantock farm; where in digging a foundation there was found below the surface soil a conglomerate, consisting of *rounded* fragments of grauwacke cemented by a deep red clay, forming a mass of extreme hardness. A short way south

of Triscombe the conglomerate appears, and may be traced to Bagborough and from thence the whole way to Bishop's Lydeard, where sections of it are seen in the side of the road.

§ 28. I have every reason to believe that nearly the whole of the rich vale of Taunton Dean is formed of rocks of this description. Mr. De Luc* describes a "red marl with blue stripes" between Blackdown and Wellington, and in the neighbourhood of Wiveliscombe he observed "at the summit of two eminences" a conglomerate in all respects the same as the Popple Rock of Vellow, which he afterwards examined.

§ 29. Near the village of St. Michael the road is cut across a ridge, and exposes a section of conglomerate and red sandstone to the depth of 20 or 30 feet, and the same rocks are found in all the intervening vallies between the ridges of the grauwacke formation which extend from Cothelstone Lodge in a south-easterly direction. The road from Bridgwater to Nether Stowey crosses the extremities of some of the lateral branches that extend from the Quantock hills, and these are entirely composed of the derivative rocks. Near Cokehurst, at a place called Mount Radford, there are some large quarries where a very hard conglomerate is worked. In composition and alternation with sandstone it is very like the series at Lawford farm, and like that contains green patches. It occurs in thick beds which are inclined at an angle of 15°. dipping north by west. In one of the quarries I observed a slip in the beds of about four feet, and the sides of the slip were covered with a smooth coating of oxide of iron similar to a slickenside. Within a mile of Stowey, where the road turns off to Taunton, there is a sandstone which is principally white, but is in some places variegated with red spots and stripes, and containing some of those green patches so general

* Geological Travels, Vol. 3. § § 1349. 1351.

in the conglomerate. In some places it is very friable, in others it forms a hard stone, in thin strata dipping gently to the north and following the inclination of the hill. Near Bincombe and Doddington it is also found, and in both those places it is very white and friable, and contains a great deal of green and blue carbonate of copper, the latter often beautifully crystallized. It was in this sandstone that the mining near Doddington, already mentioned, § 16. was begun. Near Ely Green it is mixed with large red patches, which are very argillaceous, and are chiefly composed of angular fragments of grauwacke; at the bottom of the section the sand becomes more compacted and seams of stratification are distinct. This sandstone I conceive to be the same as that which lies upon the conglomerate at Alcombe.

§ 30. Besides the conglomerates and the sandstone that accompany them, there is a member of the same series which requires to be more distinctly pointed out. It is a red argillaceous sandstone, containing a variable quantity of calcareous matter, but its most characteristic feature is its being always accompanied by spots and stripes of a greenish colour. These greenish parts are of all sizes, from a mere speck to such a degree of magnitude that they often exceed the red portion of the rock, and when this is the case they become much more indurated, and contain a larger proportion of carbonate of lime. There is seldom any marked line of boundary, the passage from the red to the greenish parts being quite gradual: it is occasionally variegated with yellow, and those places abound with dendritical delineations of manganese. It is of a uniformly fine texture, and I never found it to contain any fragments, either angular or rounded. It is the same rock which covers so great a portion of the Midland counties of England, which contains the gypsum of

Derbyshire and Staffordshire, the salt mines of Cheshire, and the brine springs at Droitwich in Worcestershire, and which is known by the name of red marl, red ground, &c. There are few rocks which present a greater variety of forms of aggregation, and about which there are so many contradictory opinions respecting its relation, in point of position, to the other secondary strata that lie contiguous to it. To investigate the mineralogical and geological history of this rock would be a most useful inquiry, and not merely as a matter of science, but in an economical point of view, from its intimate connection with the coal formations. There is undoubtedly in the district I am now describing an appearance of this rock having a common origin with the other varieties of the derivative rocks, as a series could without difficulty be collected, shewing an insensible gradation from the one to the other, and the patches of greenish sandy clay I have mentioned in the conglomerates § § 24, 26, are another strong point of resemblance. It never has been ascertained, I believe, what is the chemical difference between these greenish grey patches, and the red rock into which they seem to graduate. In many other places this red marly sandstone is accompanied by similar conglomerates, and I observed in the collection of my friend, G. B. Greenough, Esq. a specimen from Alderley Edge, in Cheshire, identical with that variety of conglomerate found at Alcombe, § 23, which contains sulphate of barytes, and carbonate of copper.—Although I found it always above the conglomerates in this district, I am informed by Mr. Greenough, that this is by no means a general rule. In that part of the district which I have already described it occurs to a very limited extent in point of thickness, but on the sea shore in the neighbourhood of Watchet, it forms, as I shall presently shew, a very prominent feature in the mineralogy of this part of the country. I found it in almost every situation where the deri-

vative rocks occur, and at their greatest elevation as at Smokeham, Crowcombe and Bagborough, but it appears to lie always above them. I did not find it in any one instance covered by the conglomerates or their accompanying sandstones.

§ 31. In the eastern part of the district near the banks of the Parret below Bridgwater there is a nearly insulated hill called Cannington Park, totally different in structure from any other part of the country described in this paper. On the north side it rises directly from the marsh land, with a gradual slope, to the height of 232 feet above the plain: on the south side it is not altogether cut off from the lateral branches of the Quantock hills. It is composed of a highly crystalline limestone, of a pearl grey colour, having a very close grain, and when struck, giving a ringing sound like that of glass. I examined it with very great care, in order to discover whether it contained any organic remains, and particularly at the decomposed surfaces, and in those places where the stone was bruised by the blow of the hammer, which generally detects any madrepores that exist in a limestone, but I could not find the slightest trace; and some of the quarriers who had worked there for several years, told me that they had never found any thing of the kind. It contains here and there contemporaneous veins of a very pure white and opake calcareous spar, and the strata are traversed by large veins of calcareous spar. In the latter veins the spar is distinctly crystallized, and in layers parallel to the sides of the vein, a circumstance which points out a marked difference between them and the veins of contemporaneous formation. On the north side of the hill there is a vein of red sulphate of barytes, about three feet thick in the widest part. This substance is not contiguous to the limestone, but is accompanied on each side by a reddish brown ochreous earth. Nor does the vein itself appear to intersect the

limestone, but to be interposed between two vertical masses. The barytes contains copper pyrites and green oxide of copper, and in the limestone near the vein I found quartz crystals scattered through the mass, giving it an appearance like a porphyry. I also observed in some places traces of carbonate of copper in the limestone.

§ 32. In going over the top of the hill (which is very much covered by vegetation) the ends of the strata appear above the grass in many places in a vertical position, and running between north-east and south-west, but on coming to the quarries where the rock is extensively exposed, I found that although it is evidently stratified, it is so shattered and so crossed by rents in every direction, that it was impossible for me to discover what were the true planes of stratification, the internal structure of the stone affording no indication. Judging however from the more general direction of the masses, I think they may be said to be either for the most part vertical, or at least very highly inclined and running between north and south. I did not discover the least appearance of slate or any circumstance that could connect this limestone with the subordinate beds in the grauwacke series of the neighbouring hills, except its proximity to them. It more nearly resembles the Plymouth limestone than any other I am acquainted with, and although that has been found to contain both madrepores and shells, there are great portions of it where no traces of organized bodies can be discovered. It is also very probable that by a more minute examination they may be found in the limestone of Cannington Park, for it has certainly very much the appearance of what is called a transition limestone, and there are laminæ of calcareous spar dispersed through it, which are strong indications of organic remains. It produces a very pure white lime, which is carried to a great distance.

§ 33. From the termination of the marsh land which lies to

the east of Minehead to that at the mouth of the river Parret there is a rocky shore, bounded by precipitous cliffs, rising in many places to the height of 100 feet. These are chiefly formed of that variety of secondary limestone, so well known by the name of lyas, together with the red argillaceous rock described § 30. The boundaries of these rocks will appear by inspecting the map, and I shall now point out the more remarkable circumstances connected with each. The great disturbances which have taken place in the strata render it extremely difficult to ascertain with precision the relative positions of these two rocks. When I first examined the coast, I observed what I conceived to be the most distinct evidence of the red rock alternating with the lyas: but as this was an important point to ascertain, being at variance with all observations in other places of the position of the lyas and red rock which I had heard of, I repeated my examination of the ground with great care, and I think it is probable that the apparently very distinct alternations of the lyas strata with the red rock are deceptions produced by those curvatures and dislocations so common on this coast, as I shall shew when I describe those places. This lyas is an argillaceous limestone of a dull earthy aspect, with a large conchoidal fracture, and generally of a light slate blue colour. It occurs in very regular strata which seldom exceed a foot in thickness, and are often not more than four inches: they are separated from each other by strata of slate clay, varying considerably in thickness. All the strata of this limestone, though externally very similar, are not of the same mineralogical composition, for they have very distinct properties. Some of them yield a lime which possesses in a most eminent degree the property of setting under water: these are generally the thinest strata, are of a light blue colour and compact earthy texture; on each surface of the stratum, and at the joints the colour is changed to a light

brownish yellow or cream colour, which is of different thicknesses, in some places extending so far into the interior of the stratum that the blue colour is nearly obliterated. I very rarely found organic remains in these beds.

§ 35. The other variety of the limestone is of a much darker colour, but is most particularly distinguished by the strong fetid smell it gives out when struck by the hammer, and when it is burning in the kilns. It is always in thicker strata than the other variety and abounds in organic remains, it is also very much penetrated by pyrites in many places. These fetid strata have much less the property of setting under water, and are best adapted for agricultural purposes, for which the other are very unfit. The quarriers on the spot call the first *blue lyas* and *building lime*, the other *black lyas* and *ground lime*. They informed me that the building lime always lies above the ground lime, and in a quarry in the parish of St. Decuman's I saw a section where the upper strata were pointed out to me by the workmen as the best building lime, and they find the strata become less adapted for that purpose the lower they go. I found the middle beds slightly fetid, and the lowest more so and increasing in thickness.

§ 36. The fossils which are very numerous in the lyas series in most places, appear to be less abundant here. The cornu ammonis is the most common, and I found it several times above 18 inches in diameter. It frequently occurs in a flattened compressed state with the beautiful iridescence of the nacre preserved; a variety which Mr. Townsend considers peculiar to the lyas of this coast.* The following are the few organic remains I had an opportunity of collecting:

Remains of a very finely striated Pecten or Lima.

* Character of Moses, p. 278. Mr. Townsend is mistaken in supposing that the Pentacrinite is not found in the lyas of Watchet.

Remains of a pentacrinite, resembling that which is found on the banks of the Severn, near to Pyrton passage.

Fragment of a large compressed and strongly ribbed ammonite.

Slight remains and traces of some unknown pinnated vegetable converted into coal.

Remains of terebratulæ, much resembling T. lacunosa.

Fragment of a large shell of the genus nautilus.

In several places the surface of the limestone strata is exposed for a considerable way, shewing that in many instances they do not consist of a continuous mass, but of an accumulation of columnar distinct concretions, resembling the Giant's Causeway on the coast of Antrim. These concretions are distinctly separated from each other, all their angles are rounded, and there is no regularity in the number of their sides or their dimensions; in some of the strata the whole surface of each concretion consists of that brown crust mentioned above, enveloping a light blue nucleus. This structure of the limestone makes it very easy to work, as it is only necessary to separate the concretions with an iron bar. In this way a great many of the beds near low water mark are worked, and the concretions are brought in paniers on the backs of little horses and asses to the kilns on the top of the cliff. I observed a similar structure in the red rock, but the divisions were much smaller than in the limestone strata. In both instances the appearance is very like that of a mass of dried clay or starch. When the strata of limestone are not divided into those columnar concretions, they are generally separated into large irregular shaped masses by joints perpendicular to the stratification, and in many parts they are penetrated in every possible direction by contemporaneous veins of calcareous spar crossing each other like network. They seldom exceed a few inches in thickness, and are in general much more slender; the same vein which in the middle is an

inch or two in thickness, gradually thins away at each extremity, sometimes to a hair's breadth, at other times shooting off like a spreading root of delicate fibres. Very often a slender thread cuts across a thick vein, throwing it several inches out of its regular course, affording a miniature representation of the disturbances in the great veins of mining districts. These veins do not penetrate the slate either above or below the stratum of limestone in which they are contained: but there are other veins of calcareous spar which cut through the strata, generally occasioning a dislocation, and in many instances I observed the substance of the vein penetrating the adjoining strata in minute ramifications. It will be difficult to reconcile these appearances to any theory of veins that has yet been proposed; like other instances, which every country affords, they tell us how little we yet know of the laws by which the materials of our globe have been brought together into their present arrangement.

§ 38. The slate clay that is interposed between the strata of limestone assumes different appearances. In some places it is grey, in others brown, and in others nearly black: it is frequently bituminous, having, when broken, a strong fetid smell. The strata are divisible into laminæ as thin as common pasteboard, splitting with the greatest facility, and where it is washed by the sea it is very soft and friable. It appears to contain the same fossils as the limestone, and it is in this that the flattened ammonites are found; those in the limestone preserving their natural form, as far as my observations went. It frequently contains imbedded masses of a limestone identical with that of the regular strata, of a lenticular shape similar in form to the masses of clay-ironstone found in the clay of the coal formations. These are frequently uniform in structure throughout, sometimes they contain slender veins of cal-

careous spar in their interior, running parallel to their shorter axis but not reaching the surface, and they are sometimes divided into septa which are coated with calcareous spar and sulphate of strontian. I was fortunate enough to break one of those masses which contained this last substance most beautifully crystallized, quite equal to many of the specimens brought from Sicily: the crystals are perfectly transparent and of a pale blue tint. It is not confined to these lenticular shaped masses, for I found it accompanying the calcareous spar of a vein in the quarries near Stringston. Thin strata of a fibrous calcareous spar are frequently found between and parallel to the strata of slate clay and limestone. They are sometimes about three inches thick, and the direction of the fibres is always perpendicular to the plane of the strata.

§ 39. About three miles and a half from the mouth of the Parret and at the termination of the low marsh land, the lyas strata first appear, rising above the sand in a highly inclined position, and nearly covering the low shore between high and low water mark. They are very much covered with sea-weed, and difficult of access from the very deep mud, but their general direction may be traced running between east and west, and dipping in some places to the north and in others to the south. After following this line of bearing a considerable way, they may be seen sweeping round in a great curve, and becoming perpendicular in their direction to the same strata not a furlong distant. They extend about a mile westward from their first rising, and then entirely disappear opposite a tract of marsh land lying between two low hills along the shore for about half a mile: at the western termination of this marsh they again appear in a highly inclined position, and a little farther west the shore begins to be bounded by cliffs, which continue without interruption to Blue

Anchor, except at those places where the brooks at Little Stoke and Donniford fall into the sea. From the place where the cliffs begin to that part of the coast which is immediately below Perry Court, they are entirely composed of the lyas strata, and that is the most eastern point where the red rock appears in the cliff.

§ 40. In the whole course of this part of the shore the strata hardly ever preserve a uniform bearing or dip for the space of a quarter of a mile, but are liable to constant changes dipping in every possible direction. It would be impossible, by any description of the particular instances of disturbance, to give an intelligible representation of the extraordinary appearance of this coast on walking over it at low water: I cannot convey a better idea of it than by comparing it to the great waves of a sea suddenly consolidated. These waves are now broken in many directions, and exhibit various sections of their internal structure. That the convolutions took place when the rocks were in a plastic state is highly probable, for the curve is complete, in many cases, without a fracture. Besides these curvatures there are in many places along the cliff, and particularly between Shurton Bars and Little Stoke, instances of those slips in the strata which are of such frequent occurrence in the coal districts. Sometimes these slips are only of a few inches, in general they are of a few feet, but they are sometimes so great that in a cliff of 100 feet high there is a complete change in the nature of the strata on each side of the slip; there being on one side of it a numerous alternation of limestone and slate clay strata, and on the other only slate clay with a very few thin beds of limestone. In general I found the line of the slip filled by calcareous spar, sometimes only a few lines in breadth and rarely exceeding a few inches, and in many instances as I have already noticed, I found the matter of the vein penetrating the

adjoining rock in slender ramifications. I found some slips where nothing appeared but the line of separation.

§ 41. The lyas formation of this part of the district is bounded on the south by a line commencing at Combwich, and passing through Bondstone and Stringston Church to the point on the coast where I have said the red rock begins, keeping a little to the north of Putsham.* The road from Knighton to Shurton Bars crosses a small valley between two hills composed of lyas, and in the bottom of this valley the red rock appears, accompanied as usual by its grey beds. This is one of the places where there is apparently a distinct instance of the red rock alternating with the lyas; for the lyas on each side of the valley and the red rock in the bottom all dip towards the same point. This however is not conclusive, for the actual contact is not seen, and the same source of error which I discovered in another place, and which I shall presently mention, may exist here: the valley stretches in a north-westerly direction and terminates on the shore near Little Stoke. I went to this place expecting to see the alternation more distinctly in the cliff; that however is wholly composed of lyas, but on proceeding along the shore in the same direction I discovered a small portion of the red rock appearing above the sand, with the lyas strata close to it on one side, but whether they lie above or below the red rock it is impossible to say, for they are, within the space of a few yards, both vertical and inclined, and dip to the north and to the south.

* Polden Hill, on the right bank of the Parret, the longitudinal direction of which is the same as that of the hills on the left bank, is composed of lyas, and near Knoll inn the red rock appears in the side of the road. I am informed by my friend Mr. Poole, of Enmore, that Pawlet Hill and Brent Knoll are also composed of lyas.

I observed the red rock in the bottom of another valley between two ridges of lyas, in the road from Benhole farm to Shurton, and here the grey indurated beds contained blue carbonate of copper. As might be expected from the disturbed state of the stratification on the coast, the lyas strata inland rise into ridges; the longitudinal bearing of these is generally from east to west: in the vallies between them patches of red soil often appear, which are no doubt owing to the red rock being subjacent.

§ 42. The northern termination of the Quantock hills descends with so rapid a slope to the sea that I expected to find a section of the grauwacke series exposed in the cliff on the shore, which in this place is above a hundred feet high: there is not however the slightest appearance of them, the whole cliff being composed of the red rock. Where the lyas and the red rock meet, the stratification of both is, in general, much confused, although at a short distance from the junction they are seen in conformable stratification. There are some very distinct instances of regular strata of lyas lying *upon* regular strata of the red rock, but in all those cases where, if the strata were continued without interruption, the lyas would lie *under* the red rock, there is always so much disturbance at the junction as to render it very doubtful whether the lyas strata are not turned up or abut against it. The strata of red rock near the junction with the lyas in this part of the cliff are nearly horizontal or dip to the north at a very small angle, but in the western part of the bay they dip south-west, and are covered by conformable strata of lyas; and in this place the grey beds of the red rock are more numerous than in the eastern part of the bay. The lyas strata continue to that part of the coast where Donniford brook falls into the sea. Here there is a kind of delta, formed of a great accumulation of gravel, consisting of pebbles of

grauwacke and quartz similar to what is found in the surrounding country. On crossing the brook the cliffs soon begin to rise again, and the lyas strata appear at the bottom covered by about 12 feet of this gravel, which becomes gradually thinner towards the west. The lyas strata continue as far as the headland on the eastern side of Watchet Harbour, and at the place of junction great confusion takes place.

§ 43. It was in this place that walking across the line of bearing of the strata at low water I discovered them in that position which leads me to think that the appearances of the red rock alternating with the lyas may be deceptions. Fig. 1. Pl. 24. is a ground plan of this part of the coast, the dark line representing the cliffs, and the faint lines the strata; *a a* being the limestone and *b b* the red rock. I found at A and B strata of lyas dipping towards the same point, and conformably with the dip of the strata of red rock at C. I therefore expected that as in going from A to B, I should cross the prolongation of the strata of red rock from C, although the ends of the strata were not much raised above the sand, I might obtain distinct evidence of the red rock alternating with the lyas: but instead of this I found the strata in the position represented in fig. 2. which is a vertical section in the line A B of fig. 1.

§ 44. The whole of the headland is composed of strata of the red rock, dipping rapidly towards the north in the cliff, but as they extend out to sea they undergo great changes, dipping to every point of the compass and with every variety of inclination. In some places they sweep round, forming a portion of a great circle with the dip of the strata towards the centre, as the lyas strata are seen to do in the eastern part of the coast. Here the grey parts of the red rock, which in general only appear as

patches, form regular strata alternating with the red, but at the planes of junction graduating into each other.

Close by the town of Watchet, in the bottom of the bay where the harbour is formed, the lyas strata appear to come from under the red rock, but as usual the junction is obscured by great disturbance. On the western side of the harbour the lyas appears for a very short distance, and abuts against the red rock: at low water the most varied curvatures and dislocations of the strata may be observed. In the red rock eastward of Watchet there are sometimes slender veins of calcareous spar running across the strata, and these, as in the lyas strata, are generally accompanied by a slip.

In this part of the coast the red rock begins to assume a new character, for it contains a large quantity of gypsum which does not appear in it eastward of Watchet.

§ 45. The coast between Watchet and Blue Anchor is composed of the red rock with grey patches, similar to that in the eastern part of the district, of another variety of it containing gypsum, of a blackish indurated clay traversed by gypsum, and of the lyas strata. All these appear in the cliffs and on the shore at different intervals, but the great disturbances in the stratification have thrown the whole into such confusion that I found it impossible during my stay to come to any satisfactory conclusion as to their relative positions. No description without the aid of plans and sections would be intelligible, and these could only be made with accuracy by a residence for some time on the spot. It would amply repay the labour of any geologist who might undertake the task, for the coast abounds with interesting phenomena, and he would probably be able to determine decisively whether the red rock does or does not alternate with the lyas strata. He would at

least find abundant proof how very enigmatical the question as to the relative position of strata frequently is; a question of the first importance in geological inquiries.

§ 46. On leaving Watchet, the red rock is for a short distance similar to what is found eastward, but veins of gypsum very soon begin to appear, and they gradually increase in quantity. The rock here is of a bright brick red colour, and very friable; and is traversed in every direction from the top to the bottom by pure white veins of gypsum. Vast blocks of it have fallen down, and are piled above each other and strewed along the shore; in those that are within reach of the dashing of the waves the gypsum is nearly washed out, giving them a very singular appearance. The rock is not distinctly stratified, but the thickest veins of gypsum are parallel to each other, and nearly horizontal: it contains as usual the grey patches and stripes. The principal veins of gypsum are of different thicknesses; in some places they nearly equal three feet, and the red rock between them is penetrated by smaller veins branching off in all directions; but besides these there are other veins which traverse the rest in every possible way. There are also detached masses of gypsum which are surrounded on all sides by the red rock.

There are different varieties of the gypsum; it is in general white, but it is in some places flesh coloured and bright red. There are thick masses of a very pure compact alabaster fit for many purposes in the arts, and there are several fibrous varieties. In some places it is mixed with siliceous sand and small pieces of quartz, and where these parts are washed by the sea, the gypsum is dissolved, and leaves the quartzose parts projecting and very often in beautiful forms. I did not find it in any case crystallized

in determinate forms, nor any appearance of its being accompanied by rock salt.

§. 47. Near Blue Anchor the cliff is composed of a blackish grey clay, containing thin beds of a slightly effervescent argillaceous stone, and which appear to graduate insensibly into the clay. These are penetrated in all directions by numerous veins of gypsum, the thickest being parallel with the strata. The same varieties are found here as in the part of the cliff near Watchet, though not so abundantly; and although there is a very great difference in the colour of the gypseous rock near Blue Anchor, and in the mode of penetration of the gypsum, I have little doubt of its belonging to the same formation as the red rock. The strata are very much disturbed, and in one place they form a complete arch dipping south-west and north-east within the space of 50 yards.

All along the bottom of the cliffs where the gypsum is found they are hollowed out by the waves dashing upon them, and where the strata dip towards the sea the upper beds hang over a considerable way in the form of a Chinese roof. Rills of water flow over them in many places, and have worn deep channels. Dr. Maton, in his Tour through the Western Counties, when describing these cliffs, says, that "the gypsum may be seen concreting under our eyes." A more attentive examination would have satisfied him that there is only decay, and no production of new matter on this coast.

§ 48. The last appearance of the lyas strata on the shore is about a quarter of a mile westward of Blue Anchor, where there is a low cliff for a short space, not rising above 12 feet. But even in this limited extent the strata exhibit great disturbance. They consist of a yellow clay, containing thin strata of limestone of a cream colour, some slender veins of gypsum, and small, earthy,

calcareous concretions. These rest upon strata of the fetid varieties, and underneath these last there are other strata of yellow clay and cream coloured limestone, and in the lowest part of the series I observed in the clay a thin bed of dark coloured limestone full of shells. In this lower yellow clay there is no gypsum.

§ 49. The lyas strata do not extend far inland from the coast. There are here, as in the country to the east, long ridges composed of them, but the surface is very little broken. There are some quarries in the parish of St. Decumans, others near the road from High Bridge to Rydon, and upon the slope of the hill eastward of Donniford.

§ 50. Westward of Minehead, in the lower part of the southern face of North hill, near Venniford, there is found a small insulated patch of the lyas strata. There is a quarry by the side of the road, and it extends in a north-west direction upon the slope of the hill as far as East Lynch, where also there are quarries. It appears to be confined to a space of about half a mile in length, and one-third of a mile in breadth. The strata in the quarry at Venniford dip at an angle of about 30° a little to the west of north: those at East Lynch are horizontal. The occurrence of this detached portion of the lyas strata is very remarkable, being above six miles distant from the last appearance of the lyas at Blue Anchor, and the high ridge of Heyden Down intervenes, which is wholly composed of the grauwacke series.

I should also notice that immediately below the quarries at East Lynch, the red rock, with grey patches appears in the side of the road. This is, I believe, the most western point where the lyas strata are found in England.

§ 51. About three miles westward of the river Parret, there occurs on the sea-shore one of the most remarkable features of

this coast, viz. the remains of a forest considerably below the level of the sea, and now only to be seen at low water.*

The first appearance of this submarine forest is opposite Stolford, about a quarter of a mile eastward of the place where a small brook runs into the sea. From this point to the mouth of the Parret there is a flat shore, which at low water is covered with a deep and almost fluid mud. The adjoining land is protected from the sea by a high bank of pebbles, composed almost entirely of the lyas limestone, and which increases in height near the place where the forest begins. Here there are seen at intervals patches of various dimensions raised six or eight inches above the sand, and upon digging into these they are found to consist of a dark brown matter resembling peat or decayed vegetable substances, mixed with a plant in which the structure is entire, with twigs and small branches of wood in a soft state, and containing here and there a few nuts. This brown matter rests upon a light blue very stiff and unctuous clay, and is of various thickness; in general from a foot to eighteen inches, but in one place I observed it two feet and a half without coming to the blue clay. Trunks of trees of a very large size are found at different intervals surrounded by the brown matter, and with their roots diverging as they grow, and fixed in the blue clay. The smaller twigs and branches in the brown matter, which look like the roots of underwood, also penetrate the blue clay, and the clay contains a great deal of that particular plant which appears the least decayed in the brown matter. Besides the trunks there are stems of great trees sunk in the brown matter and strewed about, but without any uniformity of direction: some of these I found 20 feet long, and many of them had lateral branches attached to them.

* This submarine forest was first pointed out to me by my friend Thomas Poole, Esq. of Nether Stowey.

In many places, but particularly nearest the blue clay, the brown matter had a strong smell resembling that of bilge water.

§ 52. In order to ascertain whether the species of any of the plants contained in the brown matter could be made out, I sent specimens of it to my friend Mr. Brown of the Linnean Society, whose eminent skill in botany is so well known, requesting him to examine them. He informs me that the plant which was best preserved was the only one upon which he could pronounce with any degree of probability, the rest being too much decayed. It resembles the common *Sea Grasswrack*, but the leaves are so much broader that he considers it more probably the *Zostera Oceanica* of Linnæus: it is worthy of remark, that Dr. Smith, in his Flora Britannica, when speaking of this plant, says, "Zostera Oceanica Linnæi, sui generis planta, nostras nunquam oras attigit."

§ 53. There are several sorts of wood, but it is difficult to say to what species they belong. I was accompanied in my examinaion of this forest by John Acland, Esq. of Fairfield, and some of his friends, who seemed to agree very generally that some of the trees were distinctly oak and yew. Of these, and particularly the latter, the texture is still entire; there are others which are soft and easily cut by the spade, but even these when allowed to dry become very tough and hard. The trunks seldom appear more than a foot above the ground, and they seem as if the stem had been broken off. Some of them however are smooth, as if sawed across, which has probably been the case, for a great deal of the timber has been carried away by the country people; and I was told by a farmer who had lived a great many years in the neighbourhood, that he recollects when there were stems standing erect above the height of a man, with lateral branches extending from them. This farmer some years ago ploughed up a part of

the forest, and took away above forty cart-loads of the trees, part of which he used as timber, and the rest as fuel; but for the latter purpose it was very unfit, on account of the offensive smell it produces when burning. He shewed me a gate post, which he said was one of the sub-marine trees; it had been put into the ground 40 years before, and was quite entire: he had no doubt of its being yew.

§ 54. From the place where the forest first appears it continues westward about three quarters of a mile without interruption, and it may be most advantageously examined opposite Ham Wall, a barrier erected against the encroachments of the sea. From this point the shore is occupied by the lyas strata for nearly two miles; when, near Shurton Bars, there is a great disturbance in the stratification, and the rocks totally disappear on the shore for some way, although they continue in the cliff to the height of 20 feet. Here, about a quarter of a mile from high water mark, more remains of the forest are found; and in this place I saw the greatest depth of the brown matter and the largest tree. It was about three feet in diameter, and from the concentric circles it was evidently of a great age: Mr. Acland had no doubt of its being an oak. It was of a dark brown colour, and had a greater degree of soundness than most of the wood that is found. There is no appearance of the forest westward of Shurton Bars, as far as I could discover, nor indeed is it likely, for the coast from a little way beyond that point is rocky, and the remains of the forest are only found in those places where the curvature of the lyas strata has formed hollow basins. Warner however, in his Topographical account of Somersetshire, mentions some remains of trees on the shore between Dunster and Minehead. I carefully examined that part of the coast without finding any thing of the kind, but they have

perhaps been washed away since the time he observed them, for in the place where the forest now exists it was formerly of much greater extent, and is evidently wearing away so rapidly by the action of the tides, that it is probable not a trace of it may exist some years hence. How far it extends out to sea it is impossible to say, for from within half a mile of low water, the shore is covered with mud.

§ 55. There is a very considerable resemblance between this submarine forest, and that on the coast of Lincolnshire observed by Sir Joseph Banks and Mr. Correa de Serra, and described by the latter in the Philosophical Transactions for 1799. I did not however find that flattened appearance of the trees which he speaks of, and the bark did not seem to be better preserved than the rest of the tree. I could not learn that any similar substratum had been found in the adjoining country, but it is stated by Mr. De Luc, that in digging new channels for the rivers Brue and Axe, eastward of Bridgwater, there was found at a great depth under the soil of the marsh, a continuous bed of peat.

§ 56. It is hardly possible to describe this interesting phenomenon without offering some conjecture as to its cause. Before any rational and well grounded theory could be formed, it would be necessary to examine with great attention the district of low land adjoining to the river Parret, and to collect all records of sections that have been made in it. The explanation that most readily occurs is that it has been caused by an encroachment of the sea on the breaking down of some barrier. But the remarkable disturbances that appear in the strata, the slips in these which must have evidently taken place after the consolidation of the rock, and the occurrence of the forest opposite that part of the coast where there are perpendicular cliffs 20 feet high, appear to me to favour

very strongly the supposition that the forest has been submerged in consequence of a partial subsidence of the land.

I have confined myself in this paper almost entirely to a description of facts, without entering into any of the geological speculations which they suggest. But as theory is the great end of all inquiries of this nature, a Geological memoir may be considered incomplete unless the facts are examined with the view of discovering what legitimate deductions may be drawn from them. My examination of this district was however so cursory as to render it impossible for me to observe the facts with that patient and minute attention which could alone entitle me to make any theoretical inferences from them. Some of the most interesting theoretical views, the recital of the facts alone will suggest to every one accustomed to reason on Geological phenomena, for there are probably few places where more remarkable proofs are to be found of the great disturbances which have taken place in the strata since the time of their first deposition. To those geologists who may hereafter examine this district, I would recommend the singular accumulations of conglomerate, described §§ 21. 23. 25, and particularly the detached hill of Tor Weston, and those near Tarr and Vellow, whether there is any evidence of some powerful cause acting on the surface, having left them in their present insulated position. The apparent alternation of the lyas strata with the red rock on the shore also deserves an attentive examination, and there appears to me an excellent opportunity in this district of investigating the history of that red rock about which so little is yet known, though occurring to so great an extent throughout England.

X. *Description of a Clinometer.*

By the Right Hon. Lord WEBB SEYMOUR, F.R.S. F.R.S.E. F.L.S.
MEMBER OF THE GEOLOGICAL SOCIETY.

[Read May 20th, 1814.]

In every description of stratified rocks the importance of determining the position of the plane of stratification, by referring it to some standard, is so obvious that to insist on it would be a needless intrusion upon the time and attention of this Society. The object of the present paper is to submit to the Society a description of an instrument contrived for the above purpose, accompanied by drawings, and to add an explanation of the method of using it. This instrument has received the name of the *Clinometer*.

The Clinometer consists of two parts, the *plate* and the *quadrant*. Plate 25, exhibits both lying horizontally, the quadrant in the position in which it lies packed in its case. Plate 26 shews the two parts put together, lying upon an inclined surface, and adjusted for an observation to determine its position. In both plates every part of the instrument is represented of the real size, and the references in the description are made to both by the same letters.

The plate represented by A, is circular and of brass. On the under surface, near the edge, it is thickened by a ring to give it greater strength. It is supported by three feet *a a a*, placed at equal distances just within the ring, and made of wood, with their ends flat and broad, of a form somewhat oval, and having its length

in the direction of the margin. Wood is preferred to metal for the feet, as less likely to slip on a smooth surface; and they are made broad at the end, to prevent the position of the plate and the firmness of its rest from being too much affected by the minute inequalities of a rough one. The flat ends of the feet are adjusted to a plane parallel to the upper surface of the plate; and the fibre of the wood is set perpendicularly, in order to prevent any derangement from the expansion and contraction of the wood attending the changes of moisture. On the upper surface near the edge, is a circle divided into degrees, which are numbered from zero to 90° through the four quarters successively in the same order; and it is of no consequence whether this is done from left to right, or from right to left. In the center of the plate is a circular hole *h*, to receive an axis on the under side of the base of the quadrant. For securing it, there is a bolt *cc*, which slides below, and is worked by a catch *d* rising through an oval hole in the plate and made flush with its surface.

B represents the quadrant, which has all its frame-work of brass. CC is its base, which traverses upon the plate; at *e* is the button of the central axis, which is secured in the center of the plate by the hollowed end of the bolt beneath, and at *f* is the clamp and milled-head screw, for fixing the quadrant to the edge of the plate in any direction. At *l* is a rectangular aperture, through which the divisions of the plate are seen, and read off by an index on the middle of the bevelled side of the aperture nearest to the central axis. DD is the graduated arch, fixed firmly to the base, and at right angles to the plane of its under surface. It is divided into degrees, which are numbered from below. At *b* is the head of a short axis passing through the center of the arch, and revolving with the motion of the radial bar *mm*, which carries with it the

spirit level EE, and the compass *o o o*. This axis is made to move with a degree of friction sufficient to support the weight of the radial bar in any position. The level turns upon its axis by two pivots *p p* set in two small plates projecting from the extremities of the radial bar, and through the same plates, immediately below the level, passes a strong conical axis *r r*, to one end of which the compass is fixed, and with which it revolves.

The compass-box has its bottom, as well as its top, made of plate-glass, and each of the two pieces is set in a cylindrical rim of brass which forms its sides. To the middle of this rim there is fixed, on the inside, an annular brass plate, silvered and graduated in the same manner both above and below. The divisions are of two degrees. There are two zeros, one in each intersection of a line passing through the center, and on both sides of each of them the divisions are numbered alike, till they meet in two *nineties*, in a line at right angles to the first. At *g* is a catch for working a bolt sliding on the outside, which lifts the needle from its pivot in the usual way, by the bent lever *s*. The needle has the north pole marked on the under, as well as the upper, side, and also an index line drawn from one end to the other.

In adjusting the different parts of the quadrant to each other regard must be paid to the following circumstances; that the axis of the level may be parallel to the line from the center of the quadrantal arch to the index on the radial bar; again, that when the radial bar is home upon the base, the axis of the level may be parallel to a line, in the plane of the base, from the center to the index of the base, and that the index of the radial bar may at the same time point to zero; also that the line of the two zeros in the compass may be parallel to the axis of the level, at least, when the plane of the compass is at right angles to that of the quadrantal arch.

The clinometer may be used to determine the position of any plane surface to which the plate can be applied, so as to admit of observation with the quadrant. The upper surface of a rock is that which presents itself most frequently, and the mode of observing it may be thus described.

As the surface of a rock afforded by a strata-seam seldom approahes to a perfect plane, a part of it must be chosen, which appears to give the mean, or average position of the stratification. If the surface be smooth, the quadrant may be fixed upon the plate, before the plate is set down upon the rock. If the surface be rough, the plate must first be set down, and adjusted by the eye, till its surface appears to coincide with the mean position of the stratification; the quadrant is then to be fixed on. In fixing the quadrant upon the plate, the clamp should be thrust upon the edge, before the button of the central axis is inserted. No regard need be paid to the situation of the zeros of the plate.

The radial bar must be set home upon the base; and while one hand presses the plate firm against the rock, the other must be applied to the head of the screw *g*, and bring the quadrant round till the level, properly adjusted by turning it upon its axis, is horizontal. Its axis will now be parallel to the line of stretch, that is, to a line determined by the intersection of the plane of the stratification with the plane of the horizon. The division on the plate, to which the index of the base points, is then to be noted, and the quadrant carried upwards to the same division in the next quarter of the plate; when it will have described an arch of 90°, and of course be now in a vertical plane, at right angles both to the plane of the stratification and to the plane of the horizon. After clamping the quadrant to the plate in this position by turning the screw *g*, the hand is shifted to the compass in order to

raise the radial bar till the level, duly adjusted on its axis, marks the horizontal line. When this has been done, and the needle has settled, the degrees on the compass are to be read off between the zero farthest from the quadrant, and the point of the needle nearest to that zero. This gives the magnetical bearing of the plane of the dip, that is, of a plane at right angles to the line of stretch on that side on which the plane of the stratification sinks below the plane of the horizon. The instrument may then be lifted from the rock, and the angle of the dip read off upon the quadrantal arch, being the angle which the plane of the stratification makes with the plane of the horizon. The bearing of the line of stretch is deduced from the bearing of the plane of the dip, as being at right angles to it. A correction for the magnetical variation gives the true position.

The roof of a cavern or of a mine, and sometimes the overhanging of a rock, may present an under surface for observation; but the instrument can scarcely be employed without an assistant to hold the plate firmly pressed upwards.

For an observation of this kind, the level and the compass-box must be inverted upon their axis, so as to have their faces turned towards the plate. The level is to be brought to the horizontal line as in the former case; but the quadrant must then be carried *downwards* through an arch of 90° and clamped by the screw. The radial bar is also to be drawn *down* till the level becomes horizontal. The magnetical bearing is read off upon the under side of the graduated plate in the compass.

The origin of the instrument is as follows:—A few years ago Mr. Griffiths, of Dublin, when making a mineralogical tour in the Highlands of Scotland, employed for measuring the dip of strata an instrument, which differed little from a common road

level, except in the size of the graduated arch, while he observed the bearing at the same time by a compass carried separately. Mr. Jardine of Edinburgh made the important improvement of having the compass mounted upon the radial bar, and placed it between the center and the graduated arch. Soon afterwards I had an instrument made in imitation of this, but, in order to reduce the radius of the arch, I had the compass fixed at the end of the radial bar. There was a difficulty in applying the base of this instrument to the surface of a rock, so as to place it with precision in the line of greatest depression, and the endeavour to remedy it led me to the idea of the plate. Two other clinometers were successively made for me upon this plan, with such further improvements as experience gave rise to; and the last was adapted for observation upon an under surface, upon the suggestion of Mr. Jardine. This last contained all the principles of the instrument in its present state, and was given as a model to Mr. Troughton, who, in making that which has now been described, introduced a more simple construction of the radial bar, and shewed that ingenuity which distinguishes every object of his labours, by other alterations conducive to strength and lightness as well as to greater ease and accuracy of observation.

The chief objection to the instrument in its present form, is the weight of the plate. But it is necessary that it should have a certain diameter, in order to admit of its adjustment by the eye to the mean plane of the stratification, and it must have a thickness sufficient to prevent it from bending much under the pressure required to hold it against a steep surface. No substance occurred besides a metal, that was not liable to some objection, particularly that of warping.

The clinometer may be employed for other purposes, besides

that of determining the position of strata. The contents of a solid contained by planes may be determined from the dimensions and relative positions of these planes, and for ascertaining the latter the clinometer may be used, where great accuracy is not wanted. Mr. Jardine has used it in gauging a pond, of which the sides were pretty regular slopes. By having the end of the button of the central axis and the bottom of the milled head screw so adjusted by grinding, that they may be in a plane parallel to that of the base of the quadrant, he has made the quadrant useful in supplying the place of a common spirit level upon many occasions.*

* The instrument may be had from Mr. Cary, Optician, in the Strand.

XI. *A Sketch of the Geology of the Lincolnshire Wolds.*

By Mr. EDWARD BOGG, Land Surveyor.

Communicated by H. WARBURTON, Esq. Secretary of the Geological Society.

[Read January 19th, 1816.]

BEING resident in a district which has been but little noticed as to its geological structure, I have drawn up the following remarks on its stratification; and though omissions may occur, yet I trust that an account of the Wolds of Lincolnshire and the adjacent country, may not prove uninteresting to the members of the Geological Society.

In conformity to the request of the Rev. Mr. Buckland, Professor of Mineralogy in the University of Oxford, I have endeavoured to trace on the annexed map, Pl. 24. fig. 4. the denudations or bassets of the chalk, the oolite limestone, and the sand strata, together with the alluvial earth and hills of the same formation, with as much accuracy as my personal knowledge and the nature of the country will admit. I have also added a sketch of a section, Pl. 24. fig. 3. on the same scale as the map with respect to horizontal distance (the elevation being merely imaginary) intended to elucidate the order of the stratification.

It is obvious that as the general dip of the strata of this district forms but a very small angle with the horizon, the superficial extent of the different beds occupies a greater stretch of country than from their thicknesses might at first be apprehended: in the section indeed, these measures are represented at considerable angles, yet by keeping the circumstance above mentioned in view, I hope it will be found to answer the purpose for which it is intended.

The marshes betwixt Louth and the sea, No. 1 of the section, consist principally of unstratified clay, with mixtures of sand and various marine depositions, which tend to prove that this mass of earth has been left by the ocean. A further confirmation of this may be derived from tracing the sites of the different old banks which once evidently formed the boundaries of the sea, which has now retired a considerable distance from them.

Proceeding westward we come to the basset of the chalk No. 2, being the highest stratum in this district. It forms the principal part of the Wold hills, extending in this section from Louth to the highest hills in Donington, a distance of about six miles: this stratum dips under the marshes; for on boring in them for water, the chalk is always found. On arriving at this, the workmen never fail to come at springs, and generally of sufficient strength to flow up higher than the surface, thereby justifying the conclusion that this bed is the uninterrupted continuation of the same chalk, the rough elevated basset of which forms the Wolds; and by the pressure of the water in which, the fountain springs obtained by boring in the marshes, are at once accounted for.

In the neighbourhood of Tetney, a village situated on the coast, are natural outlets of water called blow-wells; their depths have never yet been ascertained, but we cannot entertain a doubt of their communicating with the chalk. These wells overflow with a

greater flux at the time of high water, and particularly at spring tides; showing that the water in the chalk communicates with the sea, a circumstance which would lead to a supposition that the sea rests immediately on the chalk at a certain depth: if so, we might possibly expect that the agitation of the water would frequently throw up chalk on the coast, which I have never yet observed.

The chalk consists of two colours, red and white, each lying in regular strata, the red being generally undermost: in the white, seams of flint are frequently met with from two to six inches thick.

The stratum, No. 3, immediately below the chalk, is a coarse brown pebbly sand without organic remains, consisting of quartz and oxyd of iron. This bed is, I apprehend, of irregular thickness; I suppose it may vary from six to ten yards, but its appearance at its basseting is very uncertain; for, being of a very loose texture and the chalk which reposes upon it being of a more compact nature, it is evident that when these parts were exposed to the action of water, the sand being less capable of resisting the washing of that element than the chalk, this latter would be left in many instances forming projecting cliffs; which time, and the well known action of the atmosphere, would crumble down over the sand, and form those declivities which now in such variety are exhibited to our view.

The next bed, No. 4, contains in nearly equal proportions oolite limestone and calcareous clay of a lightish grey color. In certain parts of this bed the clay divides the seams of stone into regular strata; in others the stone is found to occur in the clay in large detached pieces. This bed never extends to any great distance beyond the chalk, forming in general a sort of step at the foot of its basset. Lumps of pyrites are frequently met with in the limestone. The thickness of the entire bed of stone and clay may be

about twelve or fourteen yards: it forms a close measure, and I apprehend supports the water collected by the open strata which repose upon it, for water is always found either in the chalk or in the ferruginous sand immediately below it, the well sinkers never having occasion in this district to go deeper.

The next in order, No. 5 of the section, is a stratum of grains of quartz, which for the most part are conglomerated into sandstone of different shades of colour, from a dark brown to a light grey, while in some places loose sand predominates. Marine shells are found in this stone, each species appearing to be restricted to certain laminæ of the stratum: in the sandy portions I have never observed any organic remains. I consider this measure as considerably thicker than either of the two incumbent ones, Nos. 3 and 4.

I now come to the lowest visible stratum in our district, No. 6 of the section, which I term the shale stratum. It generally makes its appearance in valleys, and its thickness I cannot estimate, for I do not know where it exhibits any thing like a denundated termination. My brother (Mr. Thomas Bogg of Louth,) and myself have bored in this stratum to the depth of a hundred yards near the village of Donington, on the west side of the river Bain, and found it to consist of the following varieties.

		Yds.	Feet	In.
1	A clay soil	1	—	—
2	Dark coloured clay	3	—	—
3	Soft grey slate with marine impressions	—	1	—
4	Blue argillaceous stone	—	—	5
5	Dark coloured clay	1	—	1
6	Soft grey slate same as No. 3	—	1	—
7	Laminated clay slightly indurated	7	2	—
8	Soft grey slate slightly inflammable	1	2	3
9	Same as No. 8. but darker coloured	1	2	3
10	Indurated clay with white marine organic remains	12	1	6
11	Same as the last but harder and blacker	2	1	3
12	Dark coloured bituminous inflammable schist	2	—	—
13	A dark blue coloured ironstone	—	—	3
14	Laminated indurated clay with white marine organic remains	11	—	—
15	Same as No. 14. but harder, with marine impressions consisting of thin leafy pyrites	3	1	4
16	Dark blue argillaceous stone	—	—	4
17	Hard indurated, laminated clay; with impressions consisting of thin leafy pyrites	6	—	4
18	Laminated bituminous schist, with white marine organic remains and inflammable	—	1	10
19	Dark blue ironstone	—	—	2
20	Laminated bituminous schist, same as No. 18	3	2	—
21	Dark blue ironstone	—	—	1½
22	Laminated bituminous schist, same as No's. 18 & 20	6	—	10½
23	Dark indurated clay, with some white marine organic remains	1	—	6
24	Laminated bituminous schist, same as No's. 18, 20 & 22	3	—	—
25	Dark indurated clay, same as No. 23	2	2	—
26	Laminated bituminous schist, same as No's. 18, 20, 22 & 24	1	1	6
27	Dark dry indurated clay, same as No's. 23 & 25, intermixed with thin seams of laminated bituminous schist	10	—	3
28	Grit	—	—	2
29	Brown laminated schist	—	—	2
30	Hardstone bind or argillaceous stone	—	2	10
31	Hard laminated, bituminous schist	—	1	2
32	Hardstone bind, same as No. 30	—	2	—
33	Hard laminated bituminous inflammable schist	—	2	4
34	Inflammable slaty bind	1	—	—
35	Hard laminated bituminous schist, very inflammable	1	—	7½
36	Hard dark blue bind interlaid with thin strata of bituminous schist	4	1	9½
37	Very inflammable schist	—	—	2
38	Hard dark blue bind, same as No. 36	1	—	8
39	Argillaceous stone	—	1	—
40	Same as No. 39, but not so hard	—	1	—
41	Hard dark blue bind, same as No's. 36 & 38 in which the boring was discontinued.	7	1	10
		103	—	—

Every variety of this stratum agrees in the two following properties, the presence of calcareous matter, which is manifested by a brisk effervescence when any part of it is submitted to the action of acids; and secondly, a more or less abundant mixture of pyrites; all the bituminous slates when exposed to the action of fire burn with a very strong offensive smell; but those found below the depth of eighty yards were not so disagreeable, in that respect, as those which were higher in the stratum. Varieties 33 and 35 were remarkable for their inflammability, and burned with a thick bituminous flame, appearing nearly equal in this respect to common coal; but after the bitumen was exhausted, the remainder was left undiminished in size. The organic remains which I have observed in this stratum as its general characteristics, are impressions of the cornua ammonis and some small bivalve shells.

The last division which I shall here notice, No. 7 of the Section, represents the alluvial collection of earth which appears to consist almost entirely of the spoils of the neighbouring strata. When these parts were deluged by water, the current evidently appears to have set in from east to west; for this collection of matter is found to consist principally of a mixture of the different strata which occur to the east of it in a state of decomposition; and in this mixture which is by no means regular, detached pieces of the beds before alluded to are found unaltered. Of these beds the chalk would expose the greatest surface to the erosion of the water, and next to this the shale would be most extensively acted on; accordingly we find that the alluvial deposition is composed of white marle and of blue, the former of which being of the least specific gravity, has overspread the higher parts and the summits of the hills, while the lower parts and the vallies are occupied chiefly by the latter. In the blue marle I have frequently found a variety of fossil shells,

and fossil wood, &c. together with specimens of all the earths and stones, more or less worn by trituration, which the district produces; I apprehend also that fragments of strata are deposited here which have come from a great depth, for pieces of very pure laminated coal are frequently to be met with which burn with a very bright light, and leave but a small residue of ash. Other pieces of jetty coal often occur breaking with a conchoidal fracture, but these agree in every respect with a thin stratum of this fossil which has been discovered at superficial depths in some situations in the shale stratum.

On the Lincolnshire coast, a considerable quantity of coal agreeing in properties and appearance with the latter of these varieties, is washed up by the sea, and is often collected by the poorer sort of the inhabitants for fuel; and along with this particular species of coal, slates similar to those in the shale measures often occur, a fact which gives us reason to suppose that the seam of coal from which these specimens have been displaced extends under the incumbent strata already noticed, into the sea, where the coal seam is denudated and from whence these washings proceed.

As the discovery of coal would be a circumstance of much importance to this country, it might be worth while to have it ascertained whether a seam of this jetty coal (called by the country people *gromel*) does not exist in sufficient thickness, and at such a depth, as would render it worth the miner's pursuit; the expense of the boring requisite for this purpose might be defrayed by a subscription among the different land proprietors in the district.

XII. *On the Tremolite of Cornwall.*

By the Rev. W. GREGOR,

HONORARY MEMBER OF THE GEOLOGICAL SOCIETY.

[Read 21st May, 1813.]

I do not know whether some observations upon a fossil of the Tremolite species, which I discovered some time since in the county of Cornwall, may be worthy the attention of the Geological Society. I was induced to record them for the following reasons. I was not aware that tremolite had ever been noticed before in our western counties. The existence of it in the particular rock which I should conceive would be classed amongst the serpentines, is not, as I am informed, an usual occurrence: and above all, I wish to draw the attention of experienced and scientific geologists to the district where this fossil was found.

I met with it nearly on the summit of a hill, in a rock which breaks forth in masses forming an irregular and picturesque ridge called Clicker-tor. It is situated about three miles from the town of Liskeard, very near to the great road which leads to Plymouth. This ridge of rock is at a considerable elevation extending in a direction from east to west, and (if I may venture to judge by the eye) for upwards of a quarter of a mile in length. It forms a very

striking feature in the neighbouring country. Blocks of the same species of rock are scattered about in different parts of the hill and in its vicinity.

This rock is of dark bottle green colour. All the specimens of it do not possess an uniform degree of hardness: they vary also in respect of fracture. The harder species frequently assumes that wavy and polished exterior surface which characterizes the magnesian stones. It is sufficiently hard to scratch glass. It has an uneven and sharp edged or splintery fracture, which exhibits no lustre. Upon examination of its surface with a pocket microscope, it appears to consist of a very fine-grained uncrystallized substance of a blackish green colour, interspersed with thin laminæ of precious serpentine of a green colour. The rock of the softer species seems to be composed of these two substances also. It has a few small greyish white specks scattered over it: these are occasioned by some softer substance imbedded in it. I am inclined to think that this substance is compact tremolite. The softer species of rock may be scratched with the nail. It has an uneven fracture, inclining to earthy. This rock abounds with iron, insomuch that the magnet is enabled to attract very small particles of it. It resists a very strong flame of the blowpipe without being fused. The fine edges however of the harder species seem to yield a little to its action.

In the side of the hill, below the ridge of rock, a quarry is opened for the purpose of supplying the neighbouring road with stones. Here the rock is laid bare in large masses. It is accompanied in some places with asbest, and also with a fine white earth, which appears from the filaments which are mixed with it, to consist of asbest broken down in a state of partial decomposition.

Between the blocks which constitute the great mass of rock, a compact substance of a greyish white colour, consisting of an assemblage of crystalline spiculæ diverging from centres, is found. The same compact fossil occurs in the body of the rock, where there has been no rent. This I found to be compact tremolite. This substance assumes also another appearance of distinct and separate crystallization. Crystals of it occur in the fissures of the rock, in a state of promiscuous and thick aggregation. They are about three-fourths of an inch in length, at the longest; and consist of thin, tabular, rectangular prisms, the angles of which are, for the most part, rounded off, so that the section of the prism appears to approach to a long ellipse. Some of these crystals possess a vitreous lustre, and are semitranspatent. In general their surface is dull, as if from the effect of weathering, and they are of a brownish ash colour resembling axinite.

Before the strong flame of the blowpipe, a fragment of a crystal melts into a greyish enamel. At the temperature 69. Fahr. I found the specific gravity of these crystals to be 3.20.

I shall not trespass upon the time of the Society by recording the minute detail of chemical experiments. I shall simply state the mode of analysis which I pursued, and the final result of it, so that I may furnish others with the means of judging whether I am warranted in calling this mineral substance a tremolite. The proportions of the several constituent parts of this fossil are given according to an average taken from 100 grains of the distinct crystals.

Acids produce very little effect upon the powdered crystals. No effervescence was produced to indicate the presence of the carbonic acid; neither could I detect any other acid as a constituent ingredient, by means of fusion with pure carbonat of potash, neutralizing

the alkali by pure nitric acid, and subjecting the solution to the ordinary tests.

Fifty grains treated in the usual way, with nitrat of barytes, &c. furnished an alkaline salt, which when united with sulphuric acid, assumed the figure of sulphat of soda by crystallization. But the quantity of this salt was too small to admit of being weighed.

One hundred grains exposed to a red heat for a quarter of an hour, were diminished in weight one grain. Pure alkalies do not effect the decomposition of this mineral so easily as they do in the state of carbonats.

One hundred grains were mixed and fused with 400 grains of dried carbonat of soda, in a platina crucible. Treated with muriatic acid spongy flocks of siliceous earth subsided. Ammonia precipitated from the decanted fluid a gelatinous matter of a reddish brown, which was sufficiently edulcorated; and after ignition, was treated with muriatic acid, which left a small portion of silica undissolved. Sulphuric acid separated some gypsum. The contents of the solution were now thrown down by means of an alcoholic solution of potash, and the brown precipitated matter was boiled with a superabundant quantity of the precipitant. The clear alkaline fluid was treated with muriat of ammonia, which separated some alumina, but in a quantity too minute for collection. Though this circumstance occurred twice, I am disposed to think that the presence of alumina should be considered as an accidental intrusion. The brown precipitated matter consisted of oxide of iron with a trace of manganese. The first solution from which ammonia could precipitate nothing further, was assayed with carbonat of soda, which separated a white matter, which was increased by boiling the fluid, even to dryness. It consisted of carbonat of lime and mag-

nesia. The lime was converted, by means of sulphuric acid, into gypsum, and thus severed from its associate.

The relative proportions of the ingredients are as follows.

Silica - -	62.2
Lime - -	14.1
Magnesia -	12.9
Oxide of Iron -	5.9
Water - -	1.
Of Manganese and Soda, a trace - - - -	—
loss - - -	3.9
	100,0

XIII. *Some Observations on the Salt Mines of Cardona, made during a Tour in Spain, in the Summer of* 1814.

By THOMAS STEWART TRAILL, M.D.

MEMBER OF THE GEOLOGICAL SOCIETY.

[Read November 3d, 1815.]

THESE celebrated mines occupy the head of a small valley in the immediate vicinity of Cardona, a town in the province of Catalonia.

This valley extends about half a mile in length, from the river Cardonero to the mines, in a direction from east-south-east to west-north-west. Its north-western side is bounded by a very steep and lofty ridge, the summit of which is crowned by the town and castle of Cardona. The opposite boundary is somewhat less elevated; but both sides are considerably higher than the upper surface of the fossil salt. On entering this valley, the attention is arrested by bold cliffs of a greyish white colour, which are soon discovered to consist of one vast mass of salt. The sides and bottom of the valley are composed of reddish brown clay, forming a thick bed, from which here and there large imbedded masses of rock salt project in the manner of more ordinary rocks; especially along the winding ascent which leads up to the town of Cardona. The summits of the ridges which bound the valley on each side, are formed of a yellowish grey sandstone of a coarse texture, and containing many scales of grey mica.

The great body of the salt forms a rugged precipice, which is reckoned between 400 and 500 feet in height at the upper extremity of the valley, and is covered by a thick bed of the clay above mentioned.

The precipitous form is partly owing to the manner in which the mine has been wrought for a series of ages. There is no excavation; but the salt has been procured by working down perpendicularly as in an open quarry. The lowest part of the present works has a solid floor of pure salt which is not above the level of the bottom of the valley where no salt is found; but the real depth of the bed of salt has never yet been ascertained. The upper surface of the salt is not level; but appears irregularly elevated, according to the general outline of the hill in which it occurs.

The salt has been usually represented as forming an entire mountain: but though it here appears supplying the place of common rock, yet from its being confined to this valley, and not attaining so high a level as the surrounding hills, it would seem more correct to consider it as a mass or bed of salt filling up a valley, than as constituting a mountain, which according to some authors* is a league in circumference. These dimensions could only be obtained by considering the neighbouring heights as formed of this mineral; a supposition not countenanced by my personal observation, nor by the best information which I could collect on the spot.

The surfaces of the salt precipice which have been long exposed to the weather are not smooth, but cut into innumerable shallow channels, running in a tortuous manner, and divided from each other by thin edges, often so sharp as to cut the hands like broken glass.

* Introduccion à la Historia Natural y à la Geografia Fisica de Espana, por Don Guillermo Bowles.—Madrid, 1775.—Dillon, who translates him. Laborde, Itineraire descriptif, &c.

The channelled surface is evidently produced by the action of the winter rains, which have given the whole a striking resemblance to the surface of a mass of ice, which had been partially thawed and again frozen.

The general colour of the exposed surface is greyish white, with here and there a tinge of pale reddish brown, from the colouring matter of the superincumbent bed of clay. Towards the extremities of the mass of salt, extremely thin layers of a pure and plastic clay are insinuated between layers of salt, so as to give it the waved delineations which often occur in some species of calcsinter. The general mass of salt is however of the greatest purity; and in order to be converted into snow white culinary salt requires no other process but grinding. The greyish hue of the external surface is owing to the rain penetrating a portion of the salt, and by diminishing its opacity, depriving it of the whiteness which the fresh fracture generally presents. At the period of my visit the surface of this immense mass was perfectly dry, and in some places, where water had most recently flowed, was covered with a snow white efflorescence. This circumstance, as well as the sharpness of the edges above mentioned, shew the little hygrometric water in the atmosphere of that country, and the general purity of the salt from earthy muriates.

The fracture of the salt is highly crystalline, and usually exhibits large granular distinct concretions, which give it sometimes the appearance of a breccia, or of containing imbedded crystals.

A perennial brine spring flows at the foot of the great precipice, and affords a strong proof of the little effect of water on this very compact salt. The aperture through which the stream has issued for many years, is not wider externally than two feet, and suddenly contracts to a few inches; while the channel worn in a solid floor of salt, through which the stream has long flowed, is not a foot in

depth. This is partly to be ascribed to the water being saturated with salt; but, during the rainy season, the stream is much augmented, and thus cannot be supposed so highly charged with saline matter. Notwithstanding this, neither the solvent nor mechanical effects of the spring seem to have much effect on the fossil salt of Cardona. The waters of this spring flow into the Cardonero, leaving in the valley a thick scaly crust of salt, resembling the ice formed around our brooks in similar situations. During the rainy season, it is asserted that the stream carries down such quantities of salt into the Cardonero as to kill the fish in that river. This assertion rests upon the authority of Bowles, an able naturalist; but he undoubtedly was led into error when he asserted, that the waters of the Cardonero at some leagues below the mines yield no trace of salt: from which he inferred, that salt may, *by motion*, be converted into earthy matter. At Manresa, which is about twenty miles below Cardona, I tested the water of the Cardonero by nitrate of silver, which indicated the presence of an unusually large portion of muriate of soda. The taste of the brine spring at Cardona is intensely saline; and the hand immersed in it, on being exposed to the air, is instantly covered with a film of salt. The salt rock near its source is most elegantly veined with delicate waved delineations of an ochre yellow colour.

The clay which covers the bed of salt at Cardona and forms the sides of the valley, exactly resembles the clay found in the salt district of Cheshire, having when dry some resemblance to shale but becoming plastic when moistened. It is remarkably pure, and free from intermixture except of salt, large masses of which are occasionally imbedded in it.

No fibrous salt was to be observed at Cardona; nor did I discover the slightest trace of gypsum in that neighbourhood; a remark which was also made by Bowles. On the soil near the town, a small quantity of a saline efflorescence was however observed, which had the taste of sulphate of soda; but the loss of the specimen I collected, has prevented a more accurate investigation of its properties.

The salt miné of Cardona is wrought like an open quarry with pickaxes and wedges, by which the mineral is raised in considerable tabular masses. The part at present wrought presents an extensive horizontal floor of pure rock salt; the level of which is a little lower than the foot of the great salt precipice. An enormous mass of the same mineral lies between this precipice and the present mine, the removal of which will, in time, render the appearance of this interesting spot still more magnificent; for then the vast front of the rock salt bed will at once strike the eye from the lowest part of the mine.

Like every other public work in Spain, the mines of Cardona are in a languid state from the effects of the late war which has desolated the peninsula. Only two labourers are at present employed in quarrying the salt, and in wheeling it to the receiving house. Over these, eight overseers are appointed, who do duty in rotation; and ten centinels are continually stationed around the mine to defend it from the depredations of the peasantry. Several clerks are employed in an office built at the entrance to the mine, and the whole is under the direction of an *Intendente* or Inspector, who wears the uniform of an officer in the Spanish army; for the mine is the property of the crown, and is most rigidly guarded. Notwithstanding the rigour with which depredators are punished, the peasantry frequently attempt to deceive the vigilance

of the guardians of the mine. When detected, the usual punishment for a peasant is, even on the first offence, two or three years labour among malefactors in some of the public works in the province. A soldier is however less severely punished when he commits a similar transgression; he is generally sentenced to a few days solitary confinement in a dungeon of the castle. On asking an overseer the reason of this disproportion in the punishment of different offenders, he replied, that the soldier's poverty was supposed to extenuate his crime, while the peasant of Catalonia enjoyed comparative wealth, and could afford to purchase salt for the consumption of his family.

Such is the boldness of the smugglers and the jealousy of the government, that it is dangerous to visit the mines without formal leave from the Intendente; as the centinels have orders to fire on any one seen loitering about them.

The workmen here receive considerable wages, and are all free labourers; each man receives daily twelve reals vellon, which at the rate of exchange last year equals three shillings sterling: lads are paid at the rate of eight reals, or two shillings; and boys receive six reals, or one shilling and sixpence.* The hours for work are from six in the morning to seven in the evening (in summer); with the intervals of half an hour, between 8 and 9 o'clock, A. M. for breakfast, and two hours, from twelve to two, for dinner, and its usual sequel in Spain, the *siesta*.

The produce of the mines is pulverized by grinding it in mills, on the exact construction of our common water mills. This ope-

* This may be considered as liberal wages where the necessaries of life, with the exception of bread, are cheap; at Cardona, mutton and beef costs 1 real vell. per 12 oz. Bread of the best quality costs 1 real vell. per 12 oz. Wine of the country (a very good red sort) is retailed at 6 quartos per bottle, or about two pence sterling.

ration reduces it into an excellent culinary salt of a snowy whiteness. In this state it is sold to the peasantry of the surrounding districts, at the rate of thirty reals vellon, or seven sh. six d. sterl. per fanega of five arrobas of Catalonia, which equal 116 pounds avoirdupois.

As there are no roads practicable for wheel carriages in this part of Catalonia, the salt is carried from Cardona on mules or asses; the only beasts of burden that could travel in safety the rugged defiles in which this district abounds. It seems a part of the perverse policy of the Spanish government to discourage the formation of proper roads, lest it should facilitate the operations of the smuggler.

It would not be difficult to connect Cardona, by means of a canal, with the ocean; and thus the valuable produce of its salt mines might increase the revenues of the crown, and the trade of Barcelona. The channels of the Cardonero and Lobregat always contain a large body of water, and might easily be rendered subservient to the purposes of inland navigation. Besides augmenting the value of the mines of Cardona, such a plan, by facilitating the intercourse with the interior of this fine province, would stimulate the exertions of a people who only require an equitable government to become highly industrious.

It yet remains that I offer a few remarks on the nature of the country around Cardona, as materials for its geology.

Its general appearance is mountainous. The mountains are abrupt, but generally wooded. The vallies are narrow, and, where the declivities will permit cultivation, they produce abundance of good grapes and some corn. In coming from Barcelona, the traveller leaves, at a small distance on the left, the majestic Montserrat; and gradually approaches a mountain chain proceding from

its northern extremity, which declines as it stretches towards Manresa. This chain consists of similar materials to Montserrat; viz. of vast beds of farcilite, composed of rounded masses of quartz, with angular pieces of siliceous slate, and fragments of clayslate united by a basis containing calcareous earth. The fragments of this farcilite become smaller as we go northward, and at last bear a striking resemblance to coarse greywacké; to which formation I am inclined to assign the puddingstone of Montserrat, and the chain of which it forms a part.*

On descending the rugged mountains of puddingstone into the valley of the Lobregat, before coming to Manresa, we observe strata of a bluish grey rock with interposed layers of a softer material of the same colour, which crumbles into sandy clay by exposure to the weather. These strata have some resemblance to sandstone-flag; but an attentive consideration convinced me that they ought to be considered as stratified greywacké approaching to greywacké slate. Above these we again find the farcilite, which is the prevailing rock about Manresa. All the rocks hitherto mentioned effervesce slightly with acids; a circumstance which connects them in some measure with the extensive limestone country to the south-west of Montserrat; and they all shew a tendency to split vertically into columnar masses. Beyond Manresa the farcilite occurs till the traveller crosses the ford of the Cardonero, when it is succeeded by a limestone of a dirty iron brown colour, and dull, almost earthy, fracture. Beyond

* It may not be improper here to remark, that the common descriptions of Montserrat, are in several respects erroneous. It is *not an insulated mountain*, as generally represented; but is the highest point of a considerable chain. Its insular appearance, as seen from the high road between Igualada and Martorel, has deceived those who have never examined its north-eastern side. The *touchstone*, mentioned by Bowles and others, as entering into the composition of its puddingstone, appears by its fracture to be only a dark coloured common siliceous slate.

the village of Suria, a sandstone, which slightly effervesces with acids, makes its appearance. This rock constitutes the sides of the valley which contain the fossil salt.

The immediate vicinity of the salt mines shews no other rock than a yellowish grey sandstone much charged with scales of mica.

We find thus that the salt rock of Cardona is accompanied by clay and sandstone, like our Cheshire salt formation. Limestone also is found near it; but the usual concomitant gypsum appears to be wanting, as well as foetid limestone. The great compactness and purity of this salt merits examination.

Though the country around Cardona is mountainous and rugged, it is inferior in elevation to the districts between it and the Mediterranean; as well as to those which bound it on the north. Immediately behind Cardona the mountains begin to ascend with increasing boldness until they unite with the grand chain of the Pyrenees.

I relinquish to others the difficult task of giving a probable explanation of the formation of rock salt; contented if my observations on the mine of Cardona can add any thing to the mass of facts which should guide us in the obscure but captivating speculations of geology.

XIV. *Description of a New Ore of Tellurium.*

By PROFESSOR ESMARK,

OF CHRISTIANIA,

FOREIGN MEMBER OF THE GEOLOGICAL SOCIETY.

[Read June 16, 1815.]

IT occurs coarsely disseminated, and crystallized in perfect hexagonal plates striped on the edges.

It has the whitish hue of tin.

Its fracture displays a perfect foliation, but only in one direction.

It has a strong metallic lustre; a moderate flexibility; considerable softness, and feels heavy.

Before the blowpipe it burns with the colour and smell of tellurium, and has the same action with acids. The precipitate by water burns upon charcoal like tellurium; but after its sublimation a small metallic button remained of the colour of silver, malleable, but too minute for further examination; for on account of the rarity of the substance, I could only devote a single grain to this examination.

It is found in the Orndal copper mine, accompanied by copper pyrites, and a small intermixture of sulphuret of molybdenum. The mine is called Mosnap, and has been full of water for several

years. The vein lies in mica slate. I met with the same ore in Hungary, in the collection of my friend M. Gerhard, who gave me a specimen of it; but as he did not know from what part of Hungary it came, he did not value it. For this reason I omitted taking notice of it in the journal of my travels through Hungary and the Bannat of Temeswar.

It is easily distinguished from molybdena, by its colour and its habitude before the blowpipe.

XV. *An Account of the Swedish Corundum from Gellivara, in Lapland.*

By C. T. SWEDENSTIERNA, of Stockholm,

FOREIGN MEMBER OF THE GEOLOGICAL SOCIETY.

[Read January, 21st, 1814.]

IN the spring of 1803, when examining a series of iron ores from Lapland which I had brought with me to Paris, I was greatly surprized to find that the porphyry mortar employed in reducing one of them to fine powder was scratched and lost its polish. Mr. Tennant having nearly at the same time published his discovery on the identity of emery with the sapphire, I was at first induced to believe that the said ore was merely a kind of emery. Upon a further examination however, I found that this ore was as soft as any other from the same place, and was chiefly composed of black and red oxide of iron. These could be separated by the magnet without leaving any earthy residue, which would not have been the case with emery, in which the cutting substance is finely divided and intimately connected with the oxide. I afterwards broke several specimens of the ore, and perceived in some of them very hard crystals the largest of which were of the size of small peas, and exhibited regular faces of an oblique octohedron. I at last succeeded in extracting about half a dozen of them of a perfectly determined form. I then no longer doubted of these crystals being a variety of corundum, which also was ascertained by my teacher in mineralogy, M. Haüy, to whom I presented the purest and most perfect specimens

I had got, and some of which have since obtained a place in the museum at Paris, and have been mentioned in the catalogue of Mr. Lucas, p. 132, under the name of *Corindon Harmophane basé.* The few remaining specimens, being all of an inferior quality, I gave to my mineralogical friends, keeping but a single crystal for my own collection, in the hope that on my return to Sweden I should easily procure a fresh supply from a large stock of Gellivara iron ore in my possession. In this expectation however I have been for the last ten years disappointed, and it is only within a few days that my search has been successful enough to furnish me with sufficient materials for a satisfactory description of this substance. The few but very excellent specimens now in my possession, and which will perfectly serve this purpose, I have been so fortunate as to pick out of several hundred pounds of Gellivara iron ores, for which I am indebted to Bar. Hermelin, the proprietor of the mines. It is rather singular that with the exception of the specimens I have mentioned, I did not discover a trace of corundum in the large quantity which was examined. I am led to believe therefore that it is by no means common, or at all events that the mines which are now worked do not furnish it in abundance. The specimen which accompanies this short memoir, and which I have the honour to present to the Geological Society, is the best and most complete among them all.

Oryctognostic description of the Gellivara Corundum.

When perfectly cleared of the grayish dust of the iron ore in which the crystals are imbedded, their colour is exactly that of common French flint.

The only form in which it has hitherto been found is that of an

oblique octohedron, more or less complete, from the size of a pin's head to that of about three lines across. Very often the crystals are so much compressed that they exhibit to the naked eye only two large faces, the lateral ones being then almost imperceptible. Sometimes the crystals are grouped two or three together, and striped parallel to the great diagonal.

The external lustre is accidental, being mostly hid by the fine powder of the matrix covering the surface, but in a fresh fracture the internal lustre is very brilliant.

The cross fracture is uneven, though approaching to the laminar. The longitudinal fracture is perfect laminar, in which direction it also can be easily divided.

The small fragments are in general undetermined, more or less pointed, often taking the form of a rhomboidal prism, the four faces of which exhibit a specular gloss.

It is semitransparent, though not so much as French flint.

Its hardness is the same as that of corundum from India.

It breaks easily in the direction of the laminæ, but in other directions not without some difficulty.

The specific gravity of two specimens was 4.20 and 4.02.*

At the blow-pipe it cannot be melted, neither alone nor with borax, &c.

Its most common and immediate matrix is a light grey coloured laminar iron ore, consisting of an intimate mixture of red and black oxide of iron, without any visible earth. This ore (a variety of eisenglanz, Werner,) which has been mentioned by Count de

* The specimens were very small, the one weighing only 1.93 grains English, the other 0.63 of a grain. They were cut and polished in order to free the substance from the iron ore with which the crystals are in general mixed.

Bournon in the Philos. Trans. 1803, is often accompanied by another coarse grained, half crystallized, loose, and more magnetic ore, by red felspar, red and white grayish phosphate of lime, and silvery coloured mica. The corundum may sometimes be found in the last mentioned iron ore, but never in the other substances, though they often make a great part of the mass. Nor has it been observed in any other variety of the Gellivara iron ores, except in a light grey coloured, fine grained, compact and very hard one, where I suspect it to be in the same close connection with the red oxide of iron as in the common emery, to which it has a great resemblance.

Geographical and Geological Remarks.

The mines of Gellivara are situated in Swedish Lapland, at 67° 10′ North latitude, about 160 English miles north-west of Torneo. The mountains in which they are wrought is almost in the center of a large country comprized between the shore of the Baltic and the Norwegian Alps, 240 miles in length, and between the two rivers of Torneo and Luleo, from 35 to 100 miles broad. The height above the Baltic is not exactly determined, but may be supposed about 1200 feet at its highest point. It rises gently on the south side, but is more abrupt on the north and east. The surrounding country is but a few hundred feet lower, and a mountain called the Dundary, at a distance of five or six miles to the east, is much higher. The whole mountain, which is about 2600 fathoms in length and from 1000 to 1600 in breadth, may be considered as a large deposit of iron ore, separated in standing layers (Stehende Lager, Werner) of different thicknesses, by a red and almost compact feldspar mixed with several other minerals. This

red felspar, in a fine grained combination with quartz and mica, is the common rock of the country, which however is never here found uncovered. It occurs only in detached blocks as well at the foot as at the highest top of the mountain, which is besides partially covered with a fine white sand to a considerable depth; with siliceous gravel and small blocks of amorphous garnet with specks of iron. Slaty quartz is also found in small fragments, but never forming a solid rock.

The above mentioned layers of iron-ore have in all the mines and all over the mountain a general direction from north-east to south-west, dipping about 45° to north-west. They very often stretch several hundred fathoms in length, and from two to three hundred in breadth, merely covered by a slight vegetation of mosses. If we except the red felspar, which at small distances runs parallel with the ore and sometimes crosses its layers, the whole forms almost a solid mass of iron, of a very considerable extent, and of an unknown depth. In those places where the ore is of a loose texture and either coarse or fine-grained, a large quantity can in an hours time be dug up by a spade. The more hard and compact magnetic ores break generally in rhombs, the angles of which are about 45°, or equal to the dipping of the layers.

The ores, of which I hope to give a more detailed account at another time, form the most complete series of iron in different degrees of oxidation, from the almost black magnetic ore to the light gray not the least magnetic, (eisenglanz, Werner,) the true substance of which shews itself by its red colour when rubbed. The greatest number of ores forming this series, may probably be considered as a more or less intimate though merely mechanical combination, between the two varieties of iron in its minimum and maximum of oxidation. The variety mentioned by Count de

Bournon may be taken perhaps as an instance of the combination in which the red oxide is found in the greatest quantity.

The minerals which occur at Gellivara, besides the corundum, in the feldspar separating the layers or within them, are chiefly the following.

1. White or grayish calcareous spar.
2. Small calcareous crystals.
3. Ditto siliceous ditto.
5. Green glassy actinolite, sometimes crystallized in four-sided prisms.
5. White pretty hard asbestus.
6. White yellowish phosphate of lime, nearly of the same colour as the corundum, commonly imbedded in a black blueish magnetic ore, forming almost one half of it, and giving to the whole mass a singular appearance.
7. Red phosphate of lime of a rosy tint and granular form. In some of the specimens I brought with me to Paris, I discovered some small but very regular hexahedral prisms of this substance, which I never met with afterwards.
8. I might also add several varieties of quartz and mica, which however mostly form with the felspar either gneiss or granite.

P. S. Since writing the above memoir I have again examined the Gellivara iron-ore, and have found amongst it some specimens of true emery.

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From the Close of the Seventh Session in June, 1814,

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I. *Donations to the Library.*

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Aug. 16.	Journal de Physique in continuation to June, 1814.	Robert Ferguson, Esq. Memb. G. Soc.
Sep. 2.	Laws of the Cornwall Geological Society, instituted at Penzance, Feb. 11th 1814. Penzance, 1814. 12°	John Ayrton Paris, M.D.
6.	On the Geological system of Werner. London, 1813. 8°	G. B. Greenough, Esq. Memb. G. Soc.
	A Catalogue of the Minerals in the Museum of Trinity College, Dublin. Part I. containing the Systematic Collection. Dublin, 1807. 8°	Robert Hutton, Esq. Memb. G. Soc.
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	Journal des Mines, in continuation for January, February, March, 1814.	Le Conseil des Mines.
	Annals of Philosophy, No. 16, 17, 18, 19, 20, 21, 22, 23; by Thomas Thomson, M.D.	The Editor.
Dec. 2.	Storia naturale della Sicilia dell'Ab. Francesco Ferrara, primario professore di Fisica nella regia università di Catania dott. di Filosophia, e medicina e socio di varie accademie. Catania, 1813. 4°	The Author.
	Resultate der Untersuchungen uber die harte und Specifische Schwere der Mineralien; von D. L. Pansner. St. Petersburg, 1813. 8°	The Author
13.	Memoire sur la determination directe d'une nouvelle variété de forme cristalline de chaux carbonatée et sur les proprietés remarquables qu'elle presente; par M. Monteiro. 4°	The Author
	Essai sur la valeur des caractères physiques employés en mineralogie; par J. Pelletier, Pharmacien, Docteur en sciences, Membre des Societés de Medicine et de Pharmacie de Paris, etc, etc. Paris, 1812. 4°	Henry Heuland, Esq. Memb. G. Soc.
	A manuscript memoir on the Antilles; by F. L. Herminier, Chimiste Pharmacien a la Basse Terre Guadaloupe.	The Author. For. Memb. G. Soc.
16.	Nouvelle description mineralogique du pyromeride globaire, ou de la Roche connue sous le nom de Porphyre globuleux de Corse; par M. Monteiro.	The Author.
	Uber die gewohrdichste Zwillingskrystallisation des Feldspathes vom Professor Weiss in Berlin.	M. Leopold Von Buch, For. Memb. G. Soc.
	Notes sur des Empreintes de corps marins trouvéesa Montmartre, dans plusieurs couches de la masse inferieure de la formation gypseuse; par M. M. Constant, Prevost et Anselme Desmarest. 1809. 8°	The Authors.
1815. *Jan.* 6.	Memoire sur la Gyrogonite; par M. A. G. Desmarest fils, Membre de la Societe philomathique de Paris. 1810. 8°	The Author.
	Extrait D'un Rapport, lu en août 1812, a la Société philomatique de Paris; par A. G. Desmarest, sur un Mémoire de M. Daudebard de Ferrussac intitulé: Considerations générales sur les Fossiles des terrains d'eau douce. Paris. 8°	. . . . .
	Memoires sur les couches naturelles de Passy; par M. A. G. Desmarest. Paris, 1813. 8°	. . . . .
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	Mineralogical Nomenclature, alphabetically arranged, with Synoptic tables of the Chemical analyses of Minerals; by Thomas Allan. Edinburg, 1814. 8°	The Author.
	A Manuel of Mineralogy; by Arthur Aikin, Secretary to the Geological Society. London, 1815. 2d edit. 8°	The Author
Feb. 12.	Description methodique d'une Collection de mineraux du Cabinet de M. de Romé De Lisle. Paris, 1773. 8°	Henry Warburton, Esq. Vice Pres. G. Soc.
	Memoire sur les Ossemens et coquilles Fossiles des environs de Plaisance; par M. Braun-Neergaard. 8°	The Hon. H. G. Bennet, Vice Pres. G. Soc.
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	Notice sur le Corindon rouge-jaunatre, de Traverselle, vallée de Brozzo; sur le Plasma de Locacana, meme vallée: sur le Manganèse couleur de rose de Picar-pra, vallée de Soana: objets qui n'avaient pas encore été découverts en Piemont; par Antoine Vagnon.	Augustus Bozzi Granville, M.D. For. Sec. G Soc.
	A Geological Essay on the Imperfect Evidence in support of a Theory of the Earth, deducible either from its General Structure or from the changes produced on its surface by the operations of Existing Causes; by J. Kidd.	The Author.

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May 1.	Annals of Philosophy; No. 29.	The Editor.
	Journal des Mines, from April to Dec. 1814.	Le Conseil des Mines
	A Practical treatise on Gas light: exhibiting a summary description of the apparatus and machinery best calculated for illuminating streets, houses and manufactories with carburetted Hydrogen, or Coal gas; with remarks on the utility, safety, and general nature of this new branch of civil economy; by Frederic Accum, Operative Chemist, &c. London, 1815. 8°	The Author.
	Meteorological diagram and Table for 1814, kept by Lord Gray at Kinfaun's Castle, North Britain.	John Mac Culloch, M.D. Pres. G. Soc.
	Prospectus of a Survey of Perthshire; by Professor Jameson.	. . . . .
19.	Journal de Physique, in continuation, to March 1815.	Robert Ferguson, Esq. Memb. G. Soc.
July 1.	Notes made during a Geological Tour through France. Manuscript.	The Hon. H. G. Bennet, Vice Pres G. Soc.
Aug. 9.	Geologie of Verhandeling over de Vorming en Vervonning der Aarde	Leonard Horner, Esq. Memb. G. Soc.
Oct. 20.	Memoirs of the American Academy, vol. 3, part 1 and 2.	The American Academy.
	Mineral System of Werner, in Manuscript.	J. H. Vivian, Esq. Memb. G. Soc.
Nov. 3.	Journal de Physique, in continuation, from April to August, 1815.	Robert Ferguson, Esq. Memb. G. Soc.
	Annals of Philosophy; by Thomas Thompson, M.D. &c., in continuation, from August to November, 1815.	The Editor.
	Journal des Mines, in continuation, for April and May, 1815.	Le Conseil des Mines
	Handbuch der Mineralogie von Hoffmann. Freiberg, 1815. 2 vols. 8°	
	Voyage a l'isle d'Elbe, suivi d'une notice sur les autres isles de la mer tyrrhénienne; par Arsenne Thiebaut de Berneaud, Secretaire émérite de la Classe de Literature, Histoire & Antiquités de l'Academie Italienne, &c. Paris, 1808. 8°	Aug. Bozzi Granville, M.D. For. Sec. G. Soc.
	Sui Sistemi Geologici Riflesioni analiteche del Cav. Ermengildo Pini., Professore di Storia nat, &c.	. . . . .
	Uber die Aechtheit der Kristalle von August. Breithaupt.	The Author.
	An Account of the Trigonometrical Survey, carried on in the years 1791, 1792, 1793, 1794; by order of the Master General of the Ordnance. London. 3 vols. 4°	**Capt. Colby, Royal Engin. Memb. G. Soc.**
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PLATES AND MAPS

IN ILLUSTRATION OF

THE THIRD VOLUME

OF THE

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY.

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1816.

EXPLANATION OF THE PLATES.

PLATE 1.

Map of Sky.

PLATE 2.

Fig. 1. Shows the marble limestone of Kilbride incumbent on the syenite, and succeeded by alternations of shell limestone and schist.

Fig. 2. Shows the alternation of marble limestone and shell limestone at Borrereg.

Fig. 3. Shows beds of Lydian stone covered by trap: at Duntulm.

PLATE 3.

Fig. 1. Illustrates the variation of the compass on the summit of Glamich.

Fig. 2 & 3. Show how a mass of trap overspreading a series of flat strata might by the casual wearing away of parts, give the appearance of having been deposited at different eras.

PLATE 4.

Fig. 1. Shows the manner in which the sandstone of Strathaird is stratified.

Fig. 2. A compound trap vein at Strathaird.

Fig. 3. Horizontal strata of sandstone intersected by trap veins: at Strathaird.

Fig. 4. A diagram shewing the supposed geological structure of Sky.

PLATES 5, 6, 7.

Crystals of Uranite from Cornwall.

PLATE 8.

Geological map of the N. E. of Ireland.

PLATE 9.

Shows the geological connexion between the W. of Scotland and the N. E. of Ireland.

EXPLANATION OF THE PLATES.

PLATES 10, 10*.

Sectional views along the N. E. coast of Ireland.

PLATE 11.

Sectional views of Kenbaan head and bay, on a larger scale than in the former plate.

PLATE 12.

Ground plan and section of Birch-hill colliery, near Walsall, Staffordshire.

PLATE 13.

Map of Glen Tilt.

The Map exhibits the general appearance of the rocks which are visible at the surface. These are distinguished by colours, of which an explanation is given in the margin. I may remark that the same colours are used to represent the same substances throughout the whole of the plates belonging to this paper.

The Map does not pretend to give every rock which comes to the surface, since the spaces which many of them occupy are so small as to have rendered such a detail impracticable. I have omitted particularly many of the small masses of quartz rock which are visible on the granite, as they would, instead of elucidating, have obscured the explanation which this map is designed to give. The southern side being of a more simple construction admitted of a more real detail, yet in this also I have not pretended to lay down the perpetual and often minute alternations of the schistose rocks with the limestone, since there would not have been room for this purpose: I have contented myself with indicating them in a general way.

In the method used in colouring, I have defined each colour in those places where the rocks themselves are visibly defined. Where these boundaries are uncertain from the covering of soil or other causes, the colours are undefined. The uncoloured parts which lie near the river are intended to represent the alluvial matter, although there is little doubt that the junction of the limestone and the granite exists below it. I have detailed as well as I could the several points where that junction is actually visible: greater accuracy would have been impracticable on the map which I was obliged to make use of, with which my own measurements were often at variance. But it is a matter of no moment for the purposes of this paper, since its object will be equally accomplished whether there are twelve or thirteen junctions visible, or whether Forest lodge is three or four miles from Gow's bridge. I have only marked one or two masses of porphyry, as a knowledge of their places was of no moment.

EXPLANATION OF THE PLATES.

PLATE 14.

This and the six following plates are intended to represent some of the most remarkable circumstances which attend the junctions of the granite with the stratified rocks. They consist of the most interesting portions, and of those which appeared to be the best calculated for explaining the different appearances which are to be seen at these points. With regard to the method used in sketching them, I must add that they are only eye views. Since the greater number of them are represented as if drawn from a point at right angles to the horizon, when they were necessarily taken at an angle often far less than this, it is plain that they will transgress the laws of perspective. But this will produce no alteration in the view they give of the geological facts, however it may derange their graphic accuracy. I have detailed the portions, most frequently, as if they had been detached, although they form in fact parts of continuous rocks. It is plain, when the magnitude of the objects represented, often extending to 40 or 50 feet, together with the minuteness of the fractures which they exhibit, often descending to the tenth of an inch, is considered, that drawings on so small a scale could not be expected to give an accurate detail of all the points in such a space. The leading features however have been marked with as much accuracy as the nature of the subject admitted, and whatever omissions or alterations may have been made, no liberties have been taken which could in any respect misrepresent the facts described in the paper and visible in the places noted.

At the upper end of this figure the granite appears to alternate with the schist. Tracing it further the true nature of the mixture is evident. The portion was selected to show a fact which has been mistaken for an alternation of schist with granite.

PLATE 15,

Represents a disturbance produced in the usual continuity of the schist and limestone, the schistose beds being abruptly broken off at their lower end. It also shows the detached points and lines of granite which are described in the paper, the limestone at the same time bearing indications of its original laminated structure, although the bed is not only here in a vertical position, but its course is also at right angles to the ordinary course of the beds which constitute the southern side of Glen Tilt.

PLATE 16,

Represents the splitting of the limestone bed into three parts, with the intrusion of two masses of granite. A confusion of the granite, schist and limestone is also visible on one side. It further represents the flexure of the limestone and the red lines of granitic matter running parallel to it, of which detached specimens are in the museum of the Society.

EXPLANATION OF THE PLATES.

PLATE 17,

Represents a more perfect example of the red lines which are found in the limestone, and these serve at the same time as indications of the bending which the limestone has undergone. Minute granite veins resembling in their composition these red parallel lines are found traversing the fragment of schist, which has lost its usual conformable parallelism to the calcareous bed.

PLATE 18,

Is selected as a representation of that utter confusion among the substances contained at the junction which almost eludes the powers of the pencil. It contains examples of all the variations which in the former drawings have been separated from each other, and in addition to those is shown an instance of the compression of the limestone bed.

PLATE 19.

To preserve uniformity in the colours which represent the different rocks I have here also tinged the limestone blue. It is white in nature. It serves to show the entire loss of the stratified character which the limestone so often undergoes in the vicinity of the granite. Specimens from this junction are also in the Society's collection.

PLATE 20.

The sections in this and the next plate are intended to represent the relative positions of the rocks, and they are founded on numerous observations throughout the Glen. The alternations are not laid down as real, nor is there any pretence to conjecture dimensions which could not be measured.

Fig. 1. Represents the case occurring at Gow's bridge where the limestone and schist are found on each side of the river. It may be said that the water has not yet wrought its way to the junction.

Fig. 2. Represents the case which predominates throughout Glen Tilt. The river here divides the stratified rocks from the granite, and has exposed the various junctions which are laid down in the map and described in the paper. It is easy to see how these will sometimes consist of limestone, sometimes of schist or of quartz rock, and sometimes of all the three substances, with the granite.

Fig. 3. Represents the case which occurs at Cairn a'chlachan, as well as in numerous other situations, and it explains the otherwise puzzling phenomenon of the apparent alternations between the quartz rock and the granite. It is easy to see that the schistose strata, once possibly lying much higher on the granite, have remained in some places while they have disappeared in others.

EXPLANATION OF THE PLATES.

Fig. 4. Is intended to represent the probable confusion which exists at the junction of the stratified with the unstratified rock. The drawings of the actual appearances at the junctions which are visible, will show that there is abundant ground for such an imaginary section.

PLATE 21.

Fig. 1. Represents the actual superposition of the rocks at the Criny, serving to justify the ideal sections which have been already given. The rocks being inaccessible are not however measured. Other indications of a similar order occur in different places, but I thought it unnecessary to represent them.

Fig. 2. Is intended to represent the probable appearance of the strata had they been deposited on the granite. Since the same beds of quartz rock, schist and limestone, are parallel among each other, they should if they had been thus deposited been also found parallel to the granite. But the actual appearance is shown in

Fig. 3, Where the strata, sometimes of limestone, sometimes of quartz rock, sometimes of schist, are found in contact with granite.

PLATE 22,

Represents the extraordinary fact occurring near Gow's bridge; the interference of beds of hornblende, schist and marble.

PLATE 23.

Geological map of the South-Western Part of Somersetshire.

PLATE 24.

Fig. 1 & 2. Represent the seeming alternation of red marle and lyas on the coast of Somersetshire.

Fig. 3 & 4. A map and section of part of Lincolnshire.

PLATES 25, 26.

Lord W. Seymour's Clinometer.

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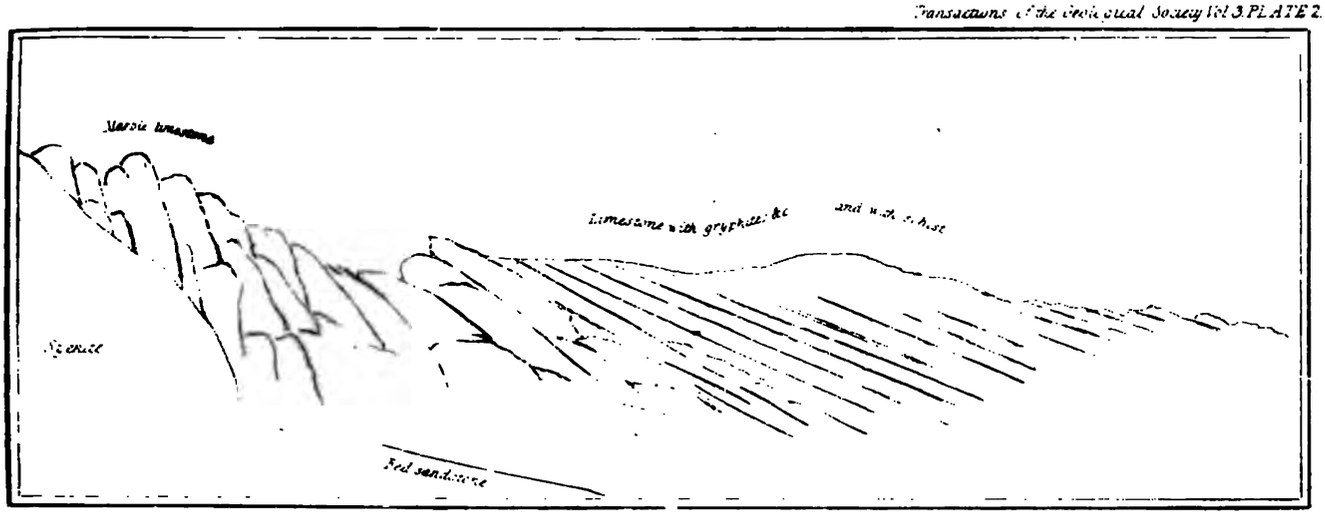
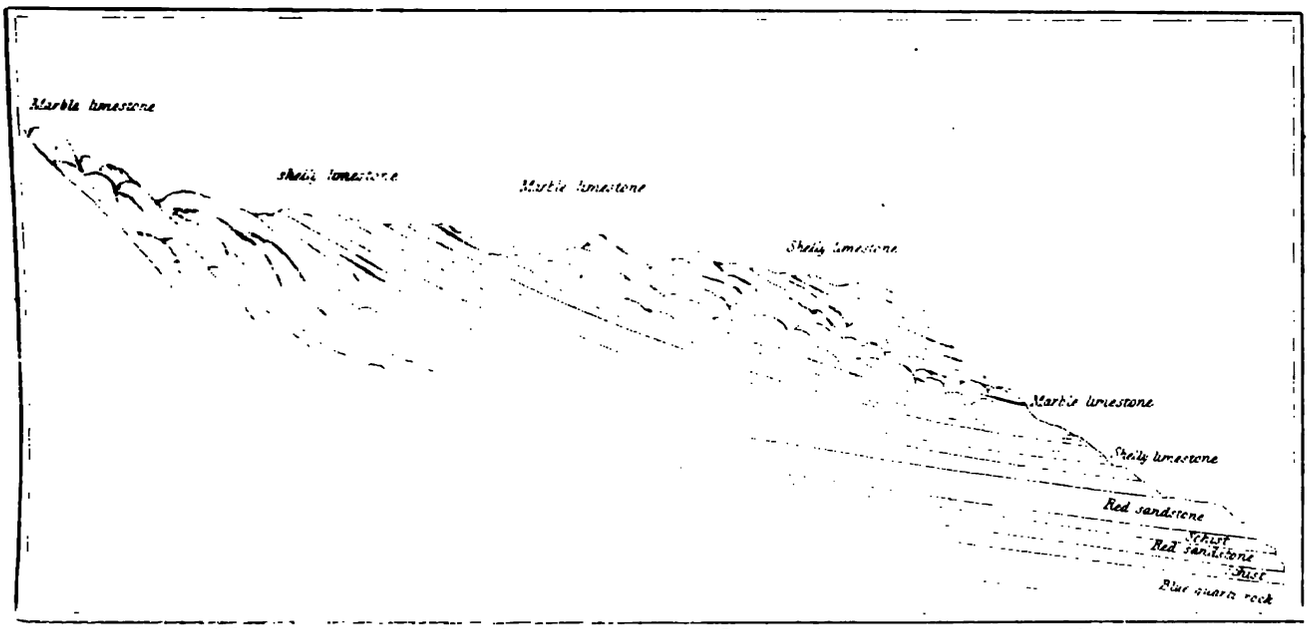
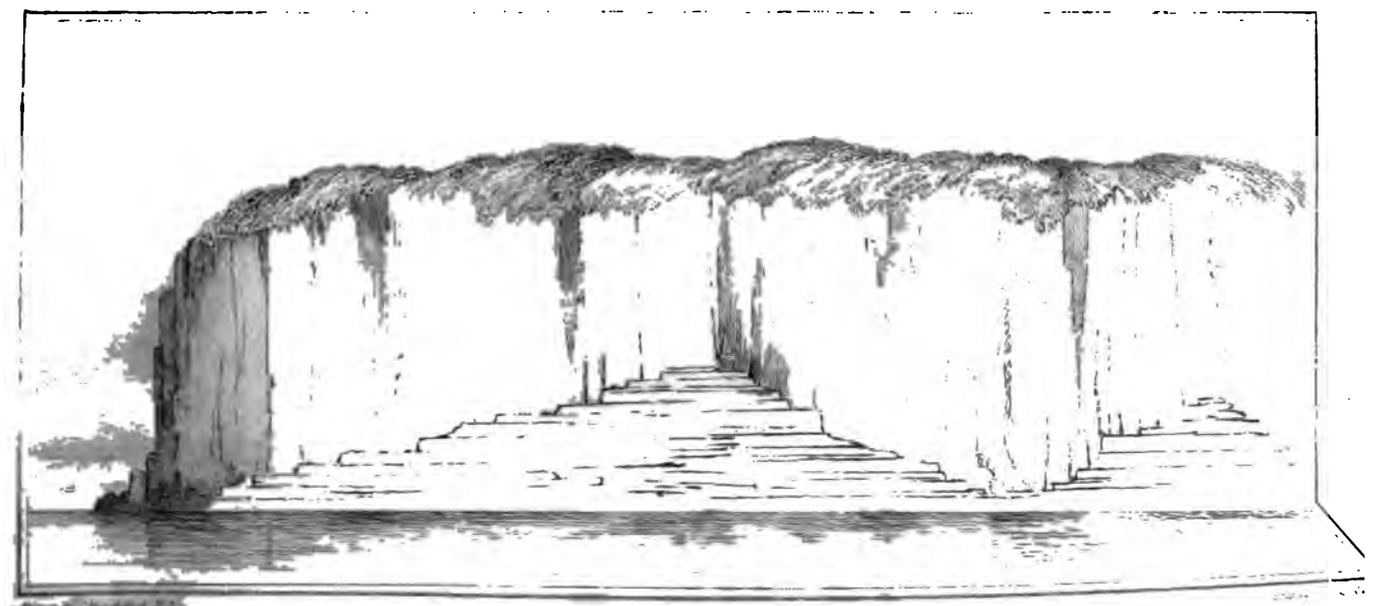


Section of limestone sandstone & Syenite at Aldbrook

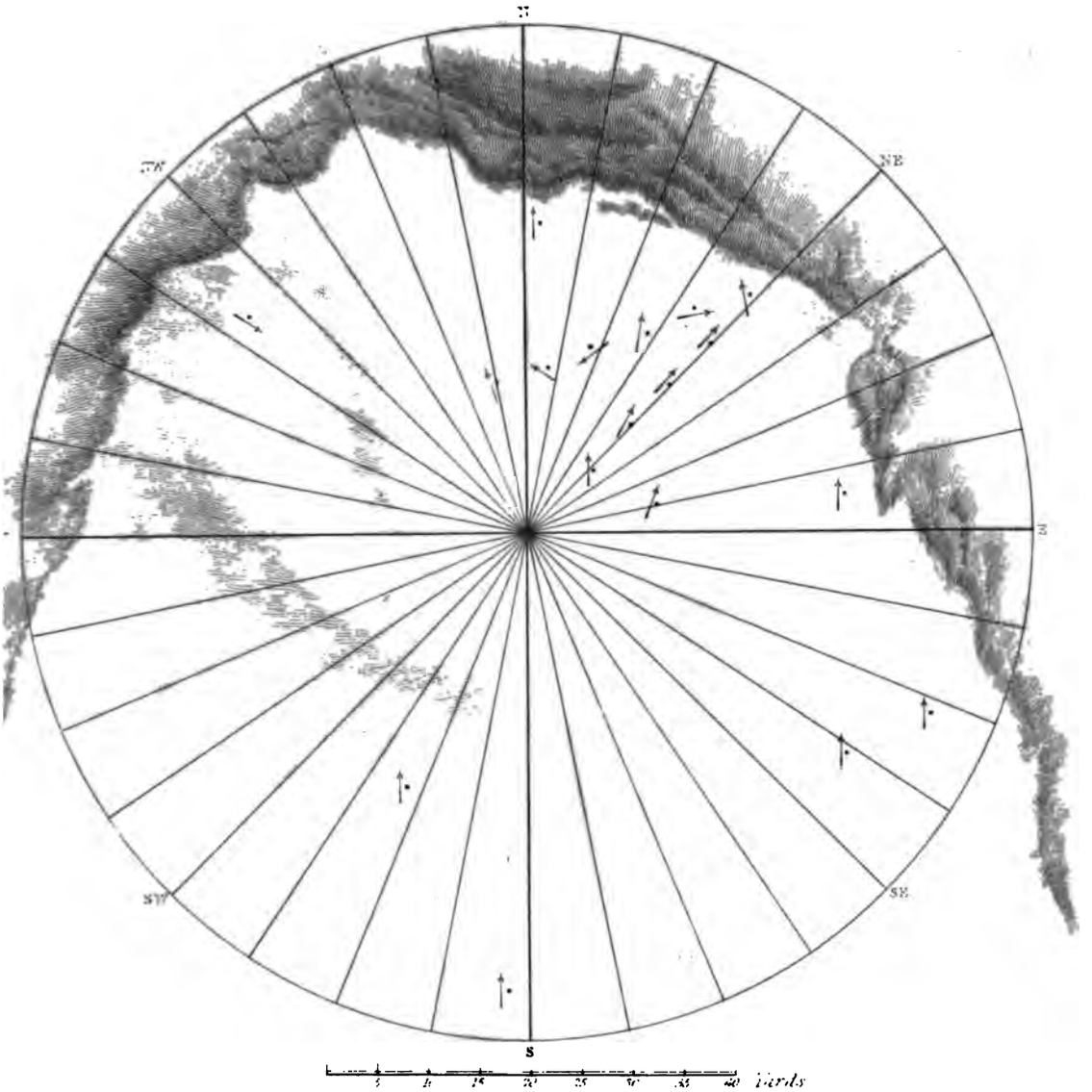


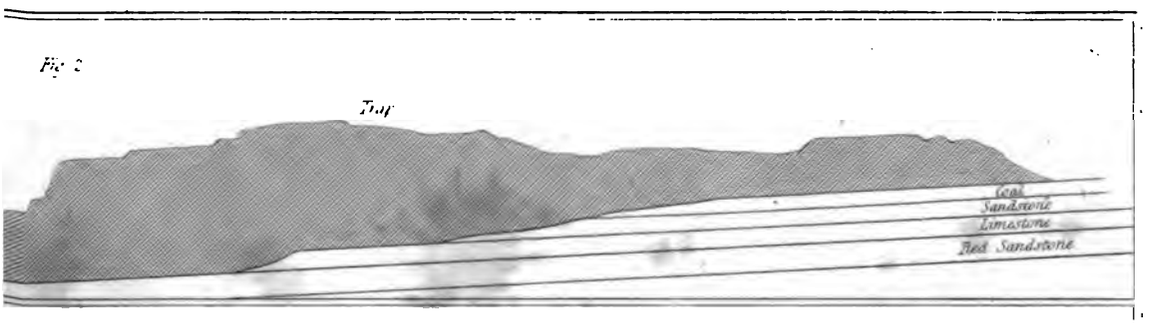
Section of the same in another direction, produced towards Berrero shewing the superposition of the strata and an example of alternation between the Shelly & the marble limestone

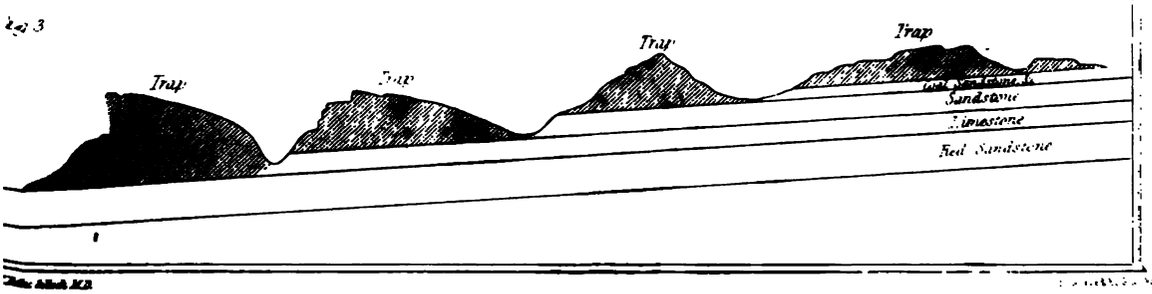


Position of the Lydian stone under the Trap at Dunsinane

Positions of the magnetic needle on the summit of Glamich in Sky.







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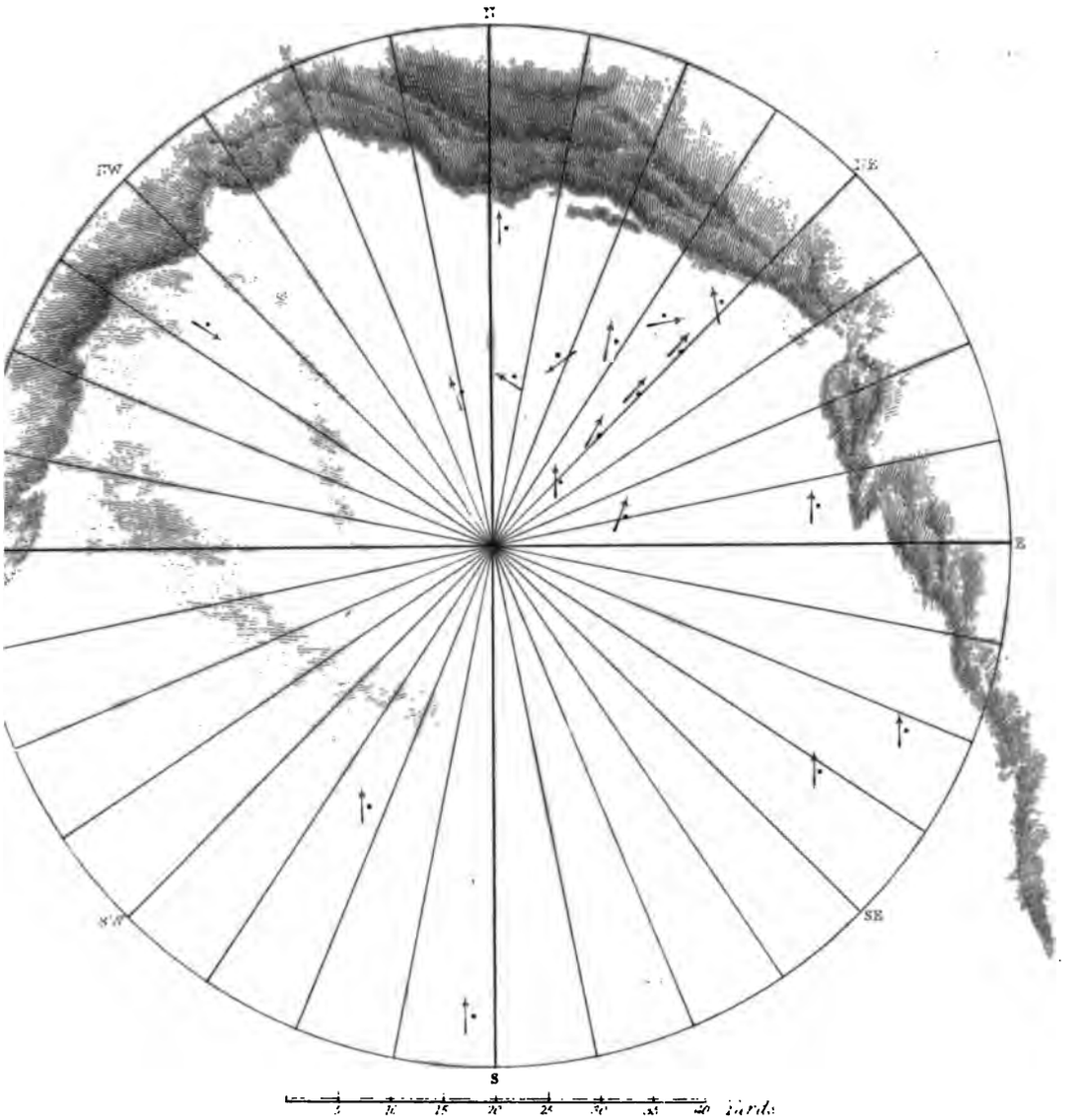
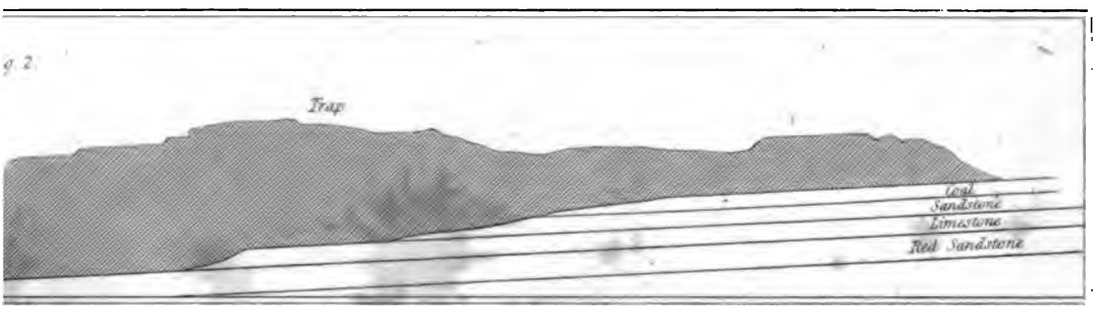
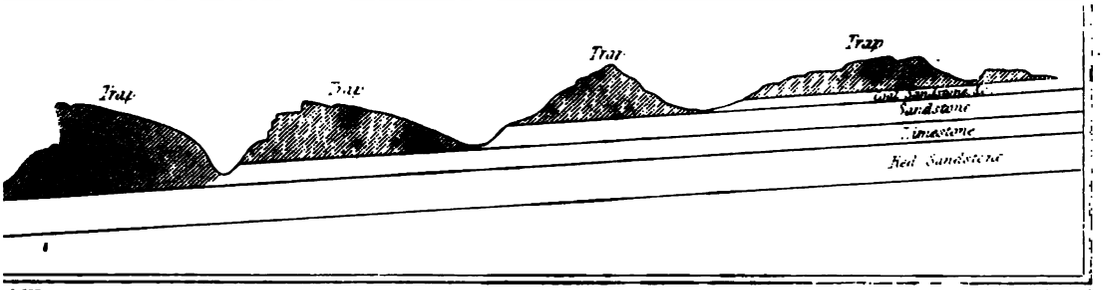
Positions of the magnetic needle on the summit of Glamich in Sky.







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Varieties of the Primitive Crystal.

Fig. 1.

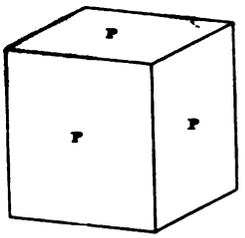
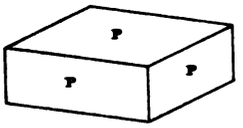


Fig. 2.



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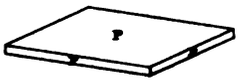

Fig. 4.

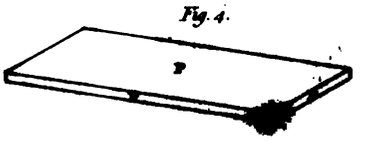

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Fig. 5.

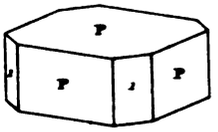
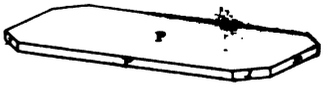


Fig. 6.

Fig. 7.



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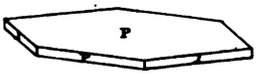


Second Modification.

Fig. 9

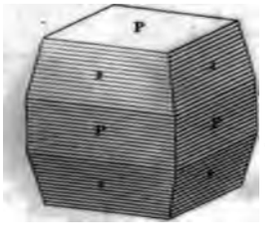


Fig. 10.

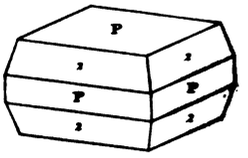
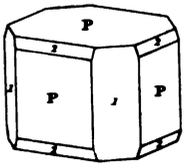


Fig. 11.



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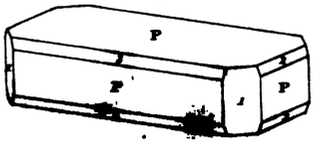

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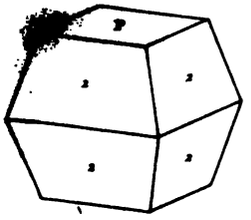

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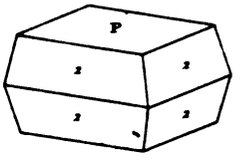
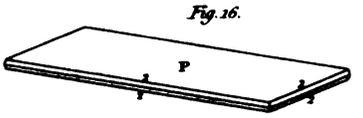


Fig. 15.

Fig. 16.



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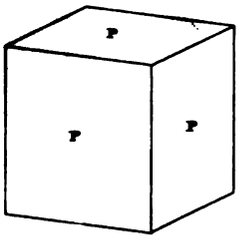
Varieties of the Primitive Crystal.

Fig. 1.



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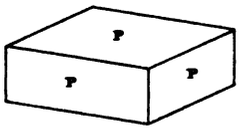

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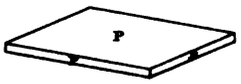

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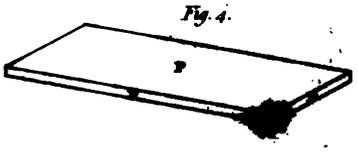

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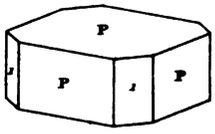
Fig. 5.



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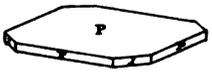

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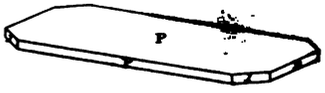

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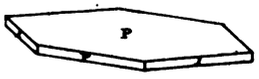
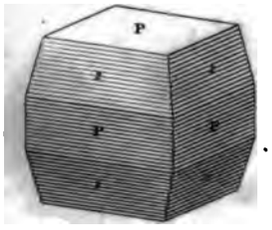


Second Modification.

Fig. 9



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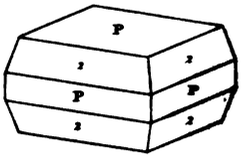

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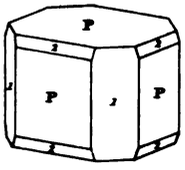

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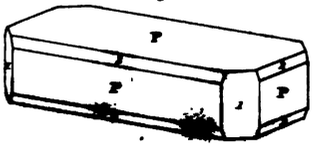

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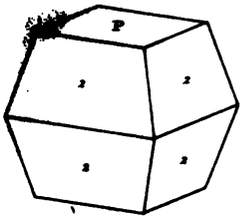

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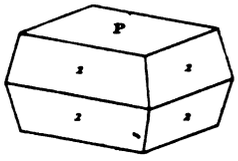
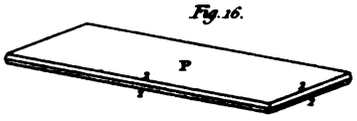


Fig. 15.

Fig. 16.



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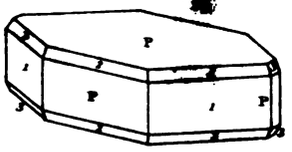
Third Modification continued.

Fig. 34.



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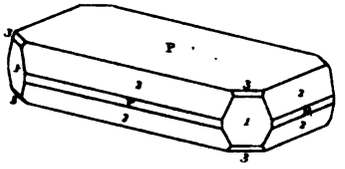

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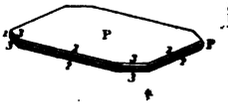

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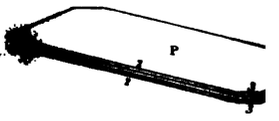

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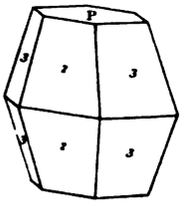
Fig. 39.



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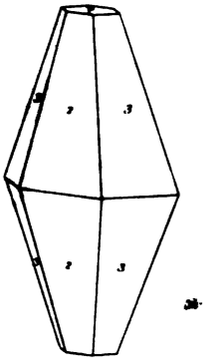

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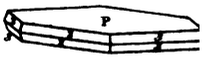
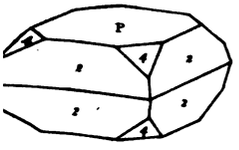


Fourth Modification.

Fig. 42.



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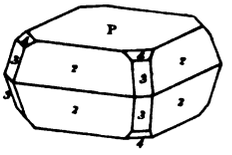

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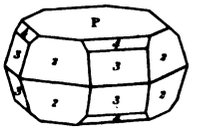

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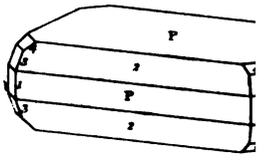
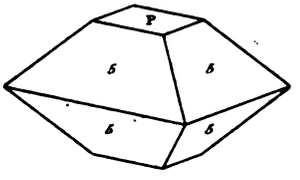


Fifth Modification.

Fig. 46.



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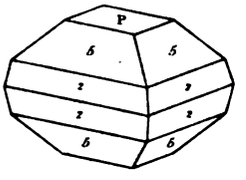

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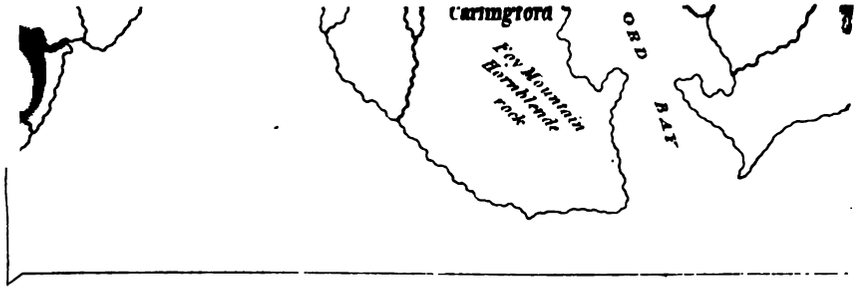
Carrington
Fox Mountain
Hornblende
rock
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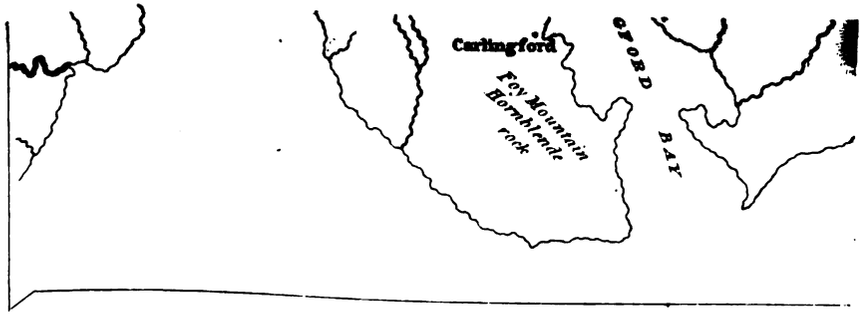
Carlingford
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rock
GYOND
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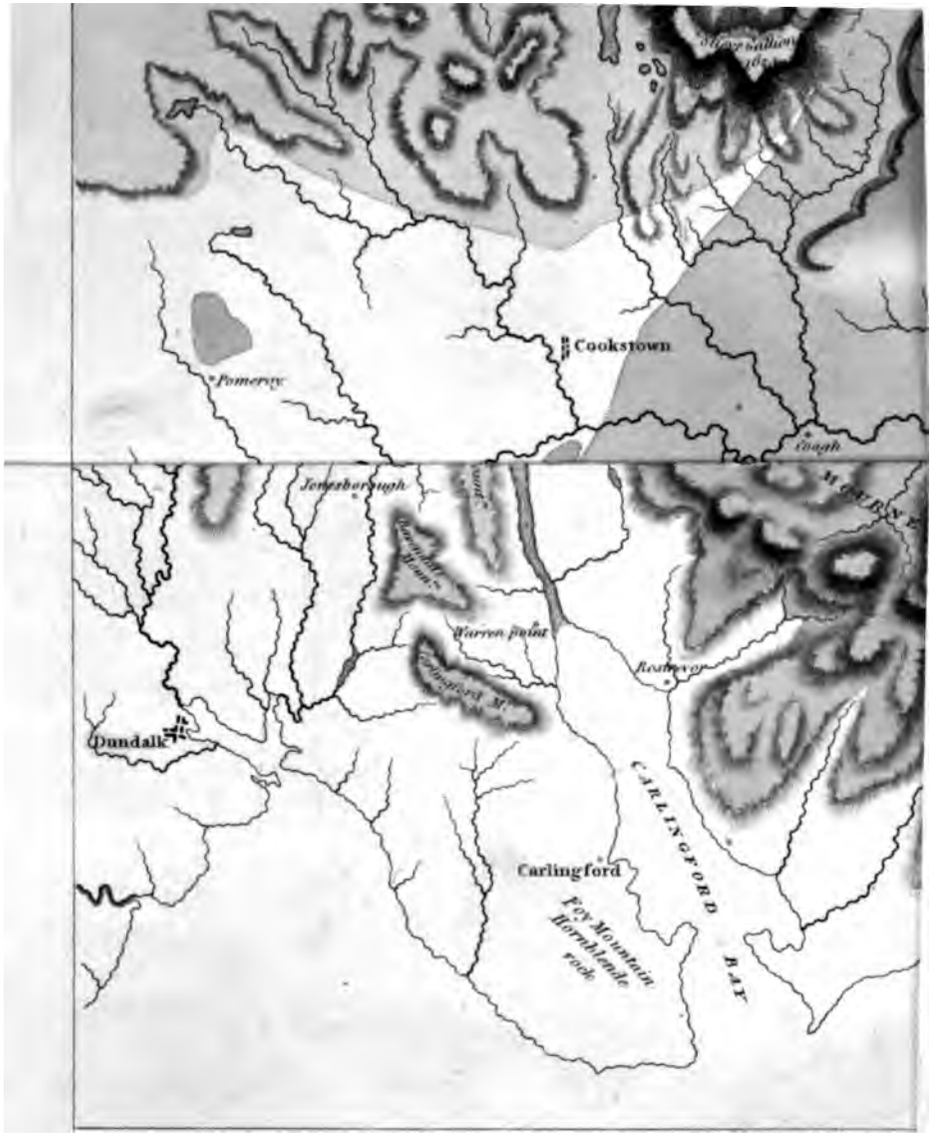
Cookstown
Pomeroy
Coagh
Jonesborough
Warren point
Rostrevor
Dundalk
Carlingford
Fey Mountain
Hornblende
rock
CARLINGFORD
BAY

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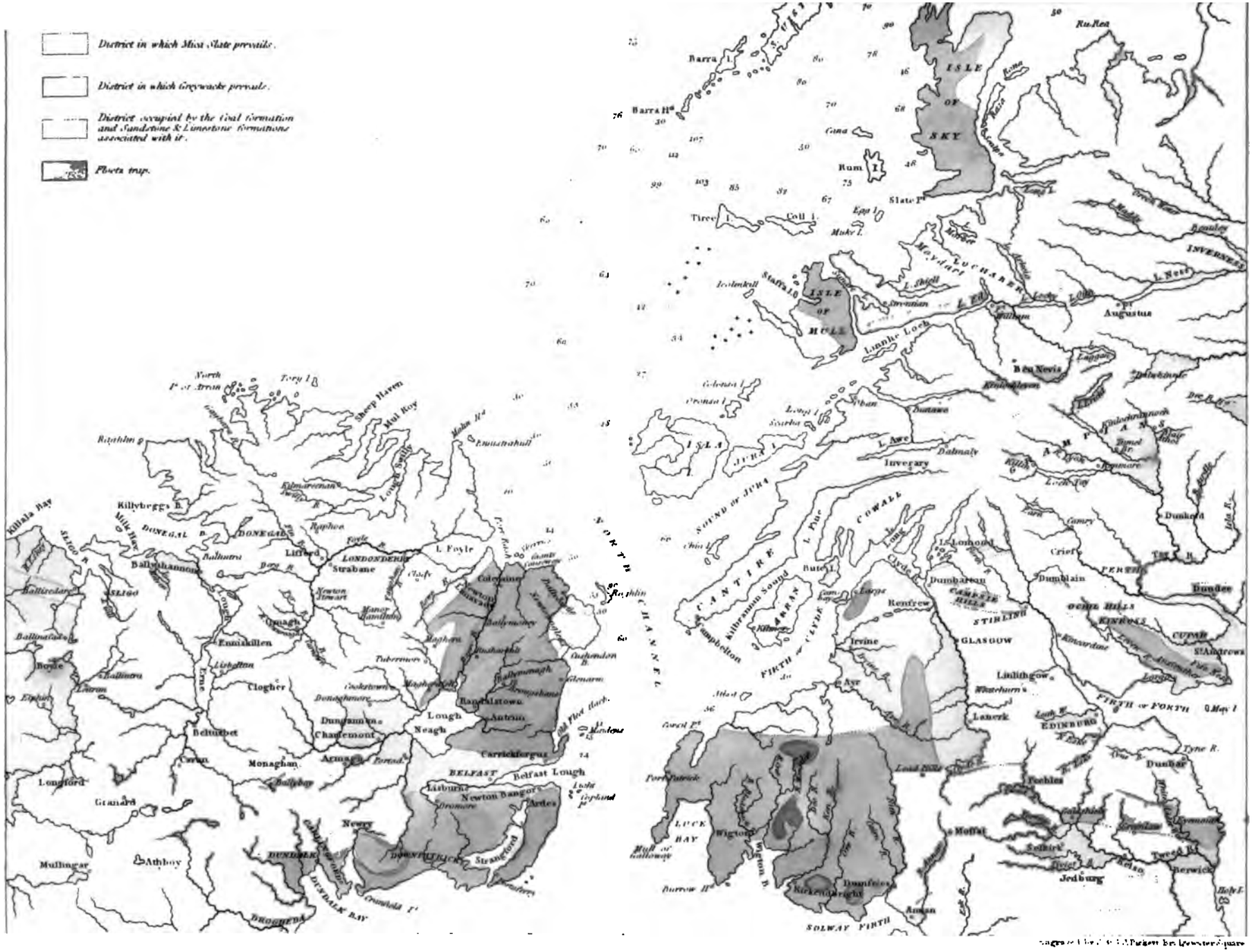
District in which Mica Slate prevails.
District in which Greywacke prevails.
District occupied by the Coal Formation and Sandstone & Limestone Formations associated with it.
Fleets trap.
ISLE OF SKY
ISLE OF MULL
ISLA
JURA
Barra I.
Barra Hd
Rum I.
Tiree I.
Coll I.
Slate Pt
Staffa I.
Iona
Ru Rea
Mayfort
LOCHABER
INVERNESS
L. Ness
Augustus
Ben Nevis
Linnhe Loch
Inveraray
L. Awe
Dalmaly
SOUND OF JURA
CANTIRE
COWALL
L. Lomond
Dumbarton
Dumbain
Dunkeld
Dundee
PERTH
OCHIL HILLS
KINROSS
CUPAR
St Andrews
STIRLING
GLASGOW
Renfrew
Irvine
Ayr
Lanark
Lithgow
EDINBURG
FIRTH OF FORTH
Dunbar
Tyne R.
Peebles
Moffat
Selkirk
Jedburg
Berwick
Tweed R.
Dumfries
Kirkcudbright
Wigton
LUCE BAY
SOLWAY FIRTH
Amen
Burrow Hd
Port Patrick
Mull of Galloway
Sheep Haven
Mull Roy
Killybegs B.
DONEGAL
Ballyshannon
SLIGO
Ballinalack
Boyle
Ballinamore
Enniskillen
Clogher
Beltinbet
Cavan
Monaghan
Longford
Granard
Athboy
Mullingar
Newry
DUNDALK
DROGHEDA
DUNDALK BAY
Strabane
LONDONDERRY
L. Foyle
Omagh
Coleraine
Ballymoney
Ballymena
Antrim
Lough Neagh
Carrickfergus
BELFAST
Belfast Lough
Newtown Bangor
Ards
Strangford
DOWNPATRICK
Dromore
Lisburn
Portadown
Armagh
Dungannon
Charlemont
Cookstown
Tobermore
Maghera
Banbridge
Rathfriland
Newtown Stewart
Manor Hamilton
Letterkenny
Rathlin
Ballycastle
Ballintoy
Killala Bay
Milk Bay
Ballinrobe
Tory I.
North Pt of Arran
Kilmarennan
Raphoe
Lough Swilly
Mahe Hd
Ennistrahull
Cushendun B.
Glenarm
Old Head dark.
Gorest Pt
Atlas
Kilkenny
Kilmacow
Kilmore
Campbeltown
Kilbrannon Sound
ARRAN
Cumbrae
Largs
Ardrossan
Kilmarnock
Lanark
Wanchurn's
Tyne R.
Dunbar
Peebles
Moffat
Selkirk
Jedburg
Berwick
Tweed R.
Dumfries
Kirkcudbright
Wigton
Amen
Burrow Hd
Port Patrick
Mull of Galloway
Sheep Haven
Mull Roy
Killybegs B.
Ballyshannon
Ballinalack
Boyle
Ballinamore
Enniskillen
Clogher
Beltinbet
Cavan
Monaghan
Longford
Granard
Athboy
Mullingar
Newry
DUNDALK
DROGHEDA
DUNDALK BAY
Strabane
LONDONDERRY
L. Foyle
Omagh
Coleraine
Ballymoney
Ballymena
Antrim
Lough Neagh
Carrickfergus
BELFAST
Belfast Lough
Newtown Bangor
Ards
Strangford
DOWNPATRICK
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Lanark
Wanchurn's
Tyne R.
Dunbar
Peebles
Moffat
Selkirk
Jedburg
Berwick
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Amen
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Port Patrick
Mull of Galloway

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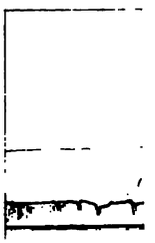

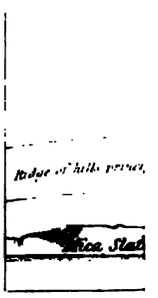

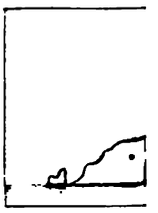

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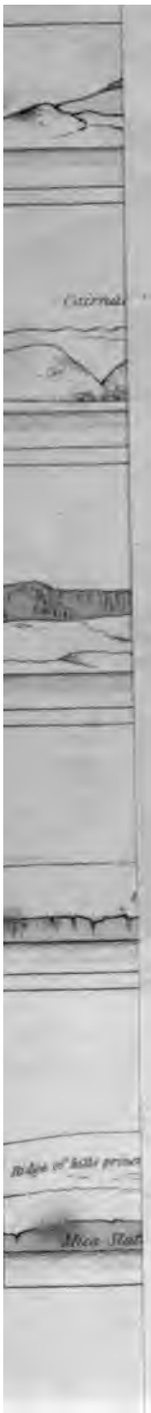

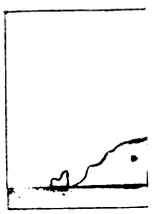

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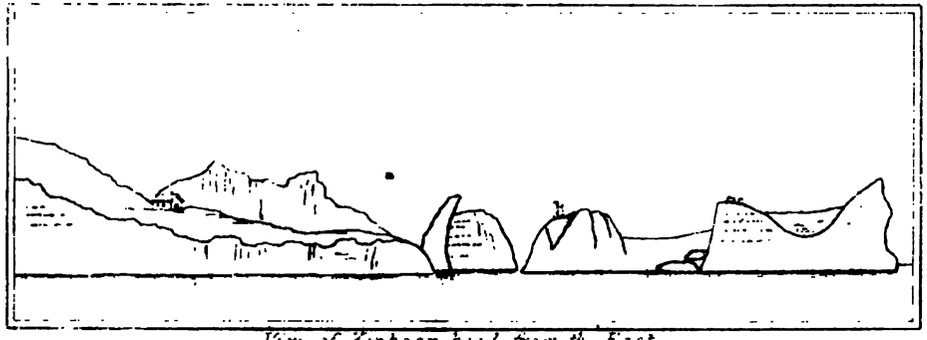
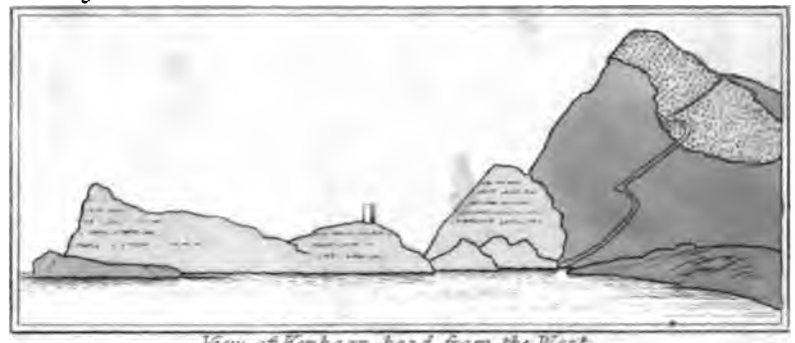
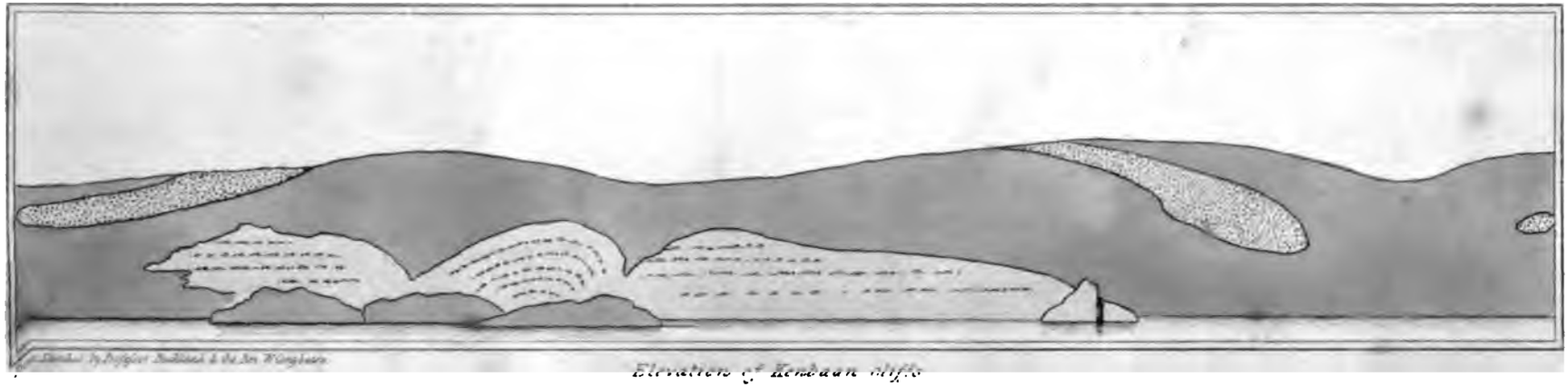
View of Kenbaan cliffs from the extreme point of Kenbaan Head



View of Kenbaan head from the East.



View of Kenbaan head from the West.



Elevation of Kenbaan cliffs

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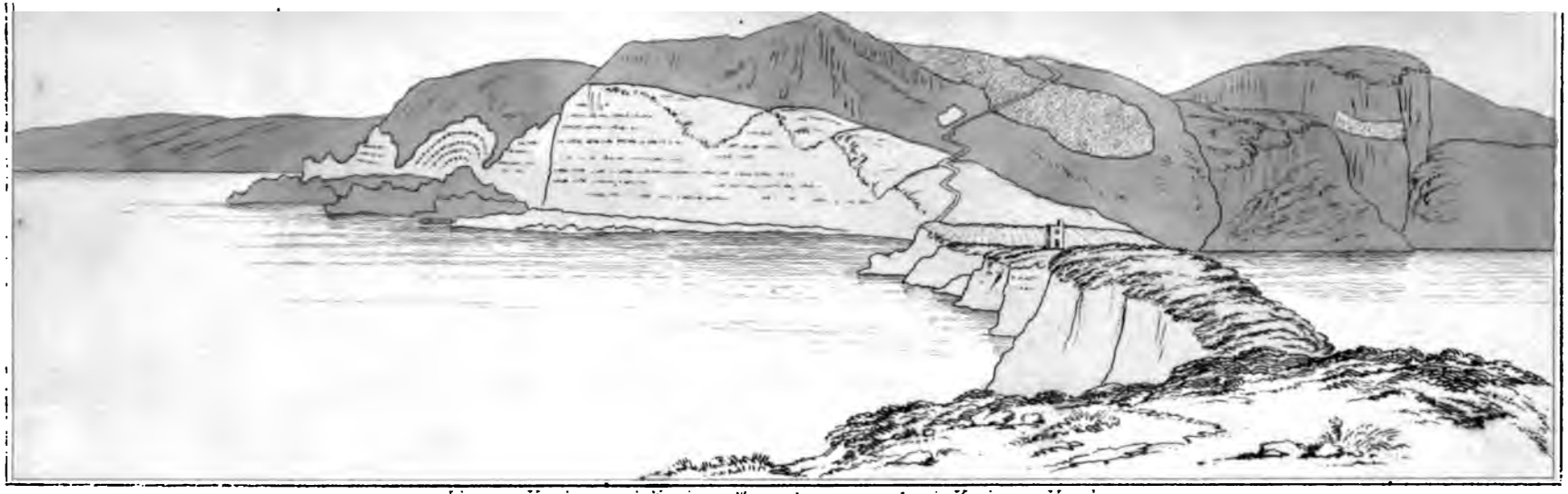
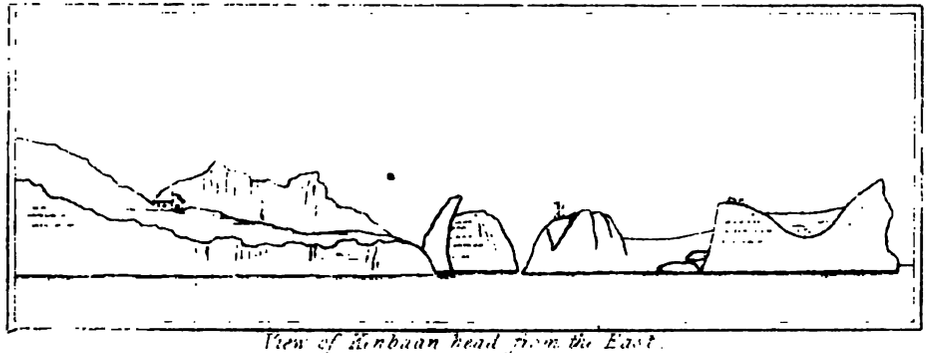
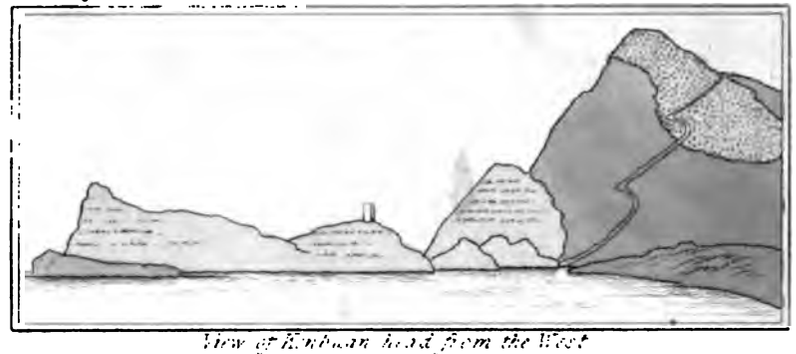


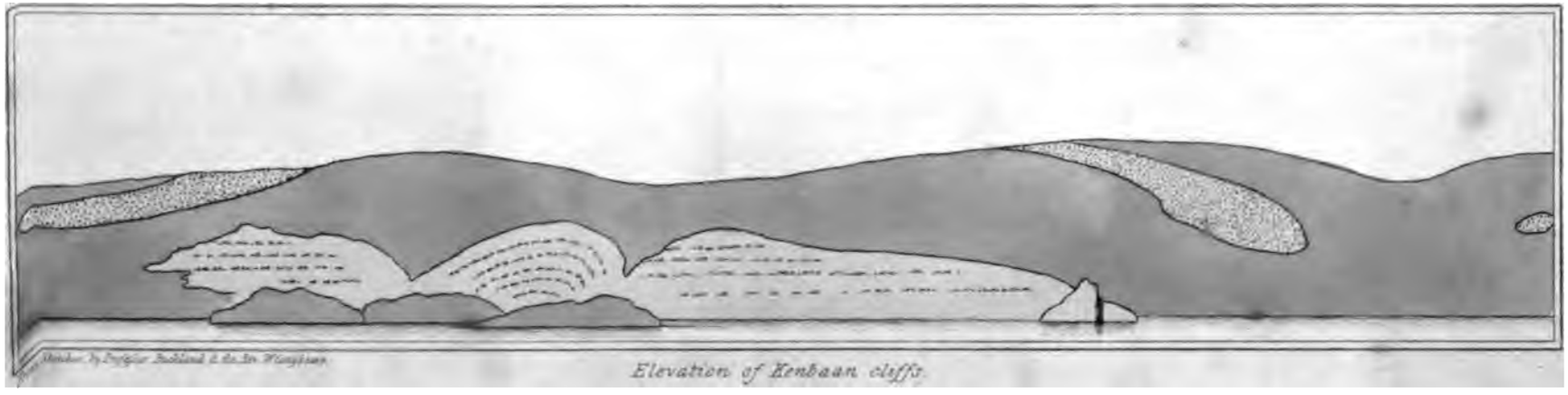
View of Kenbaan cliffs from the extreme point of Kenbaan Head



View of Kenbaan head from the East.



View of Kenbaan head from the West



Drawn by Captain Rutland & Mr. Mr. Hampshire

Elevation of Kenbaan cliffs.

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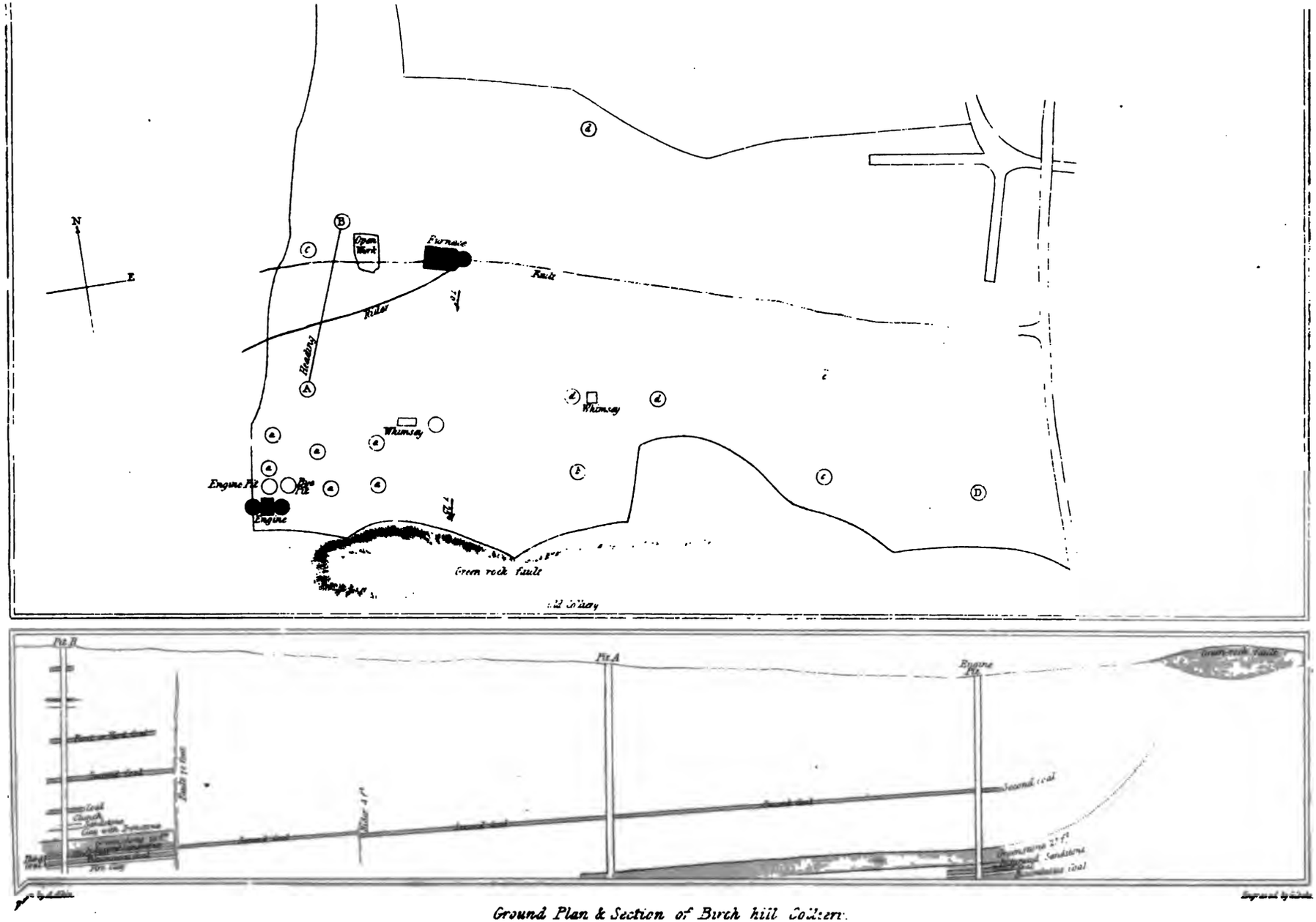

Ground Plan & Section of Birch hill Colliery.

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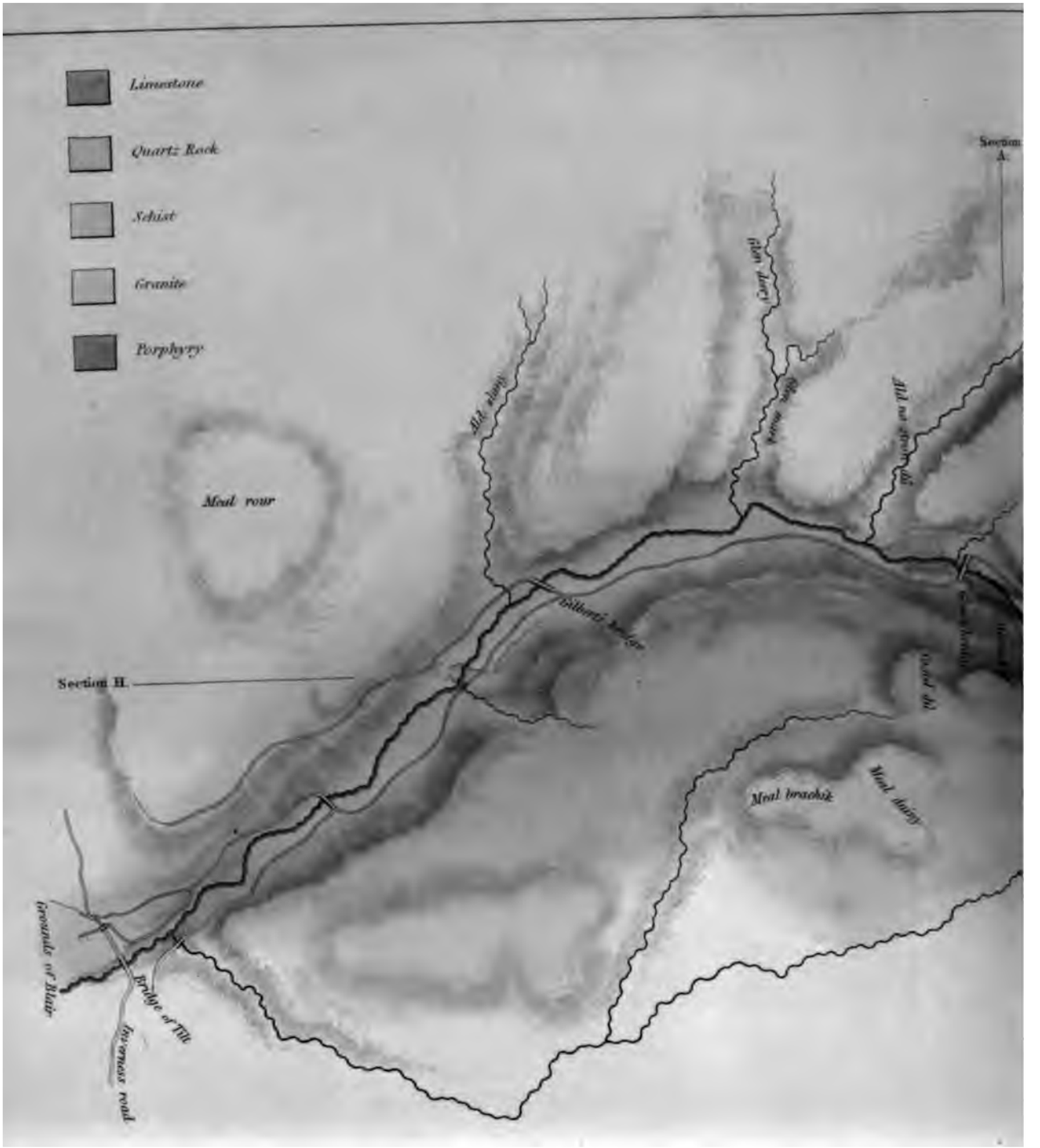
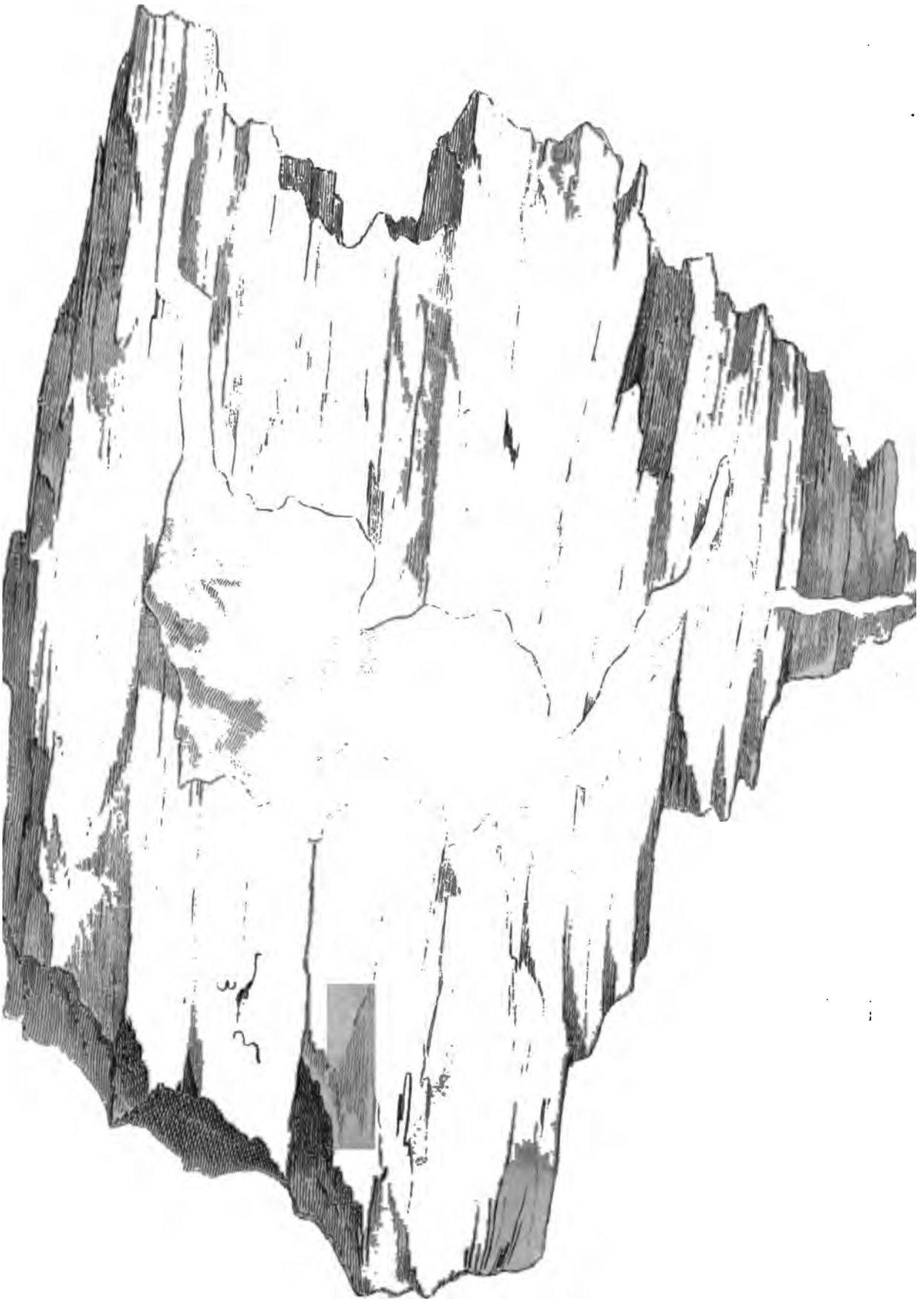


wn by I.Maccalloch 1813

Section
C.
Cairn
vardoch
D



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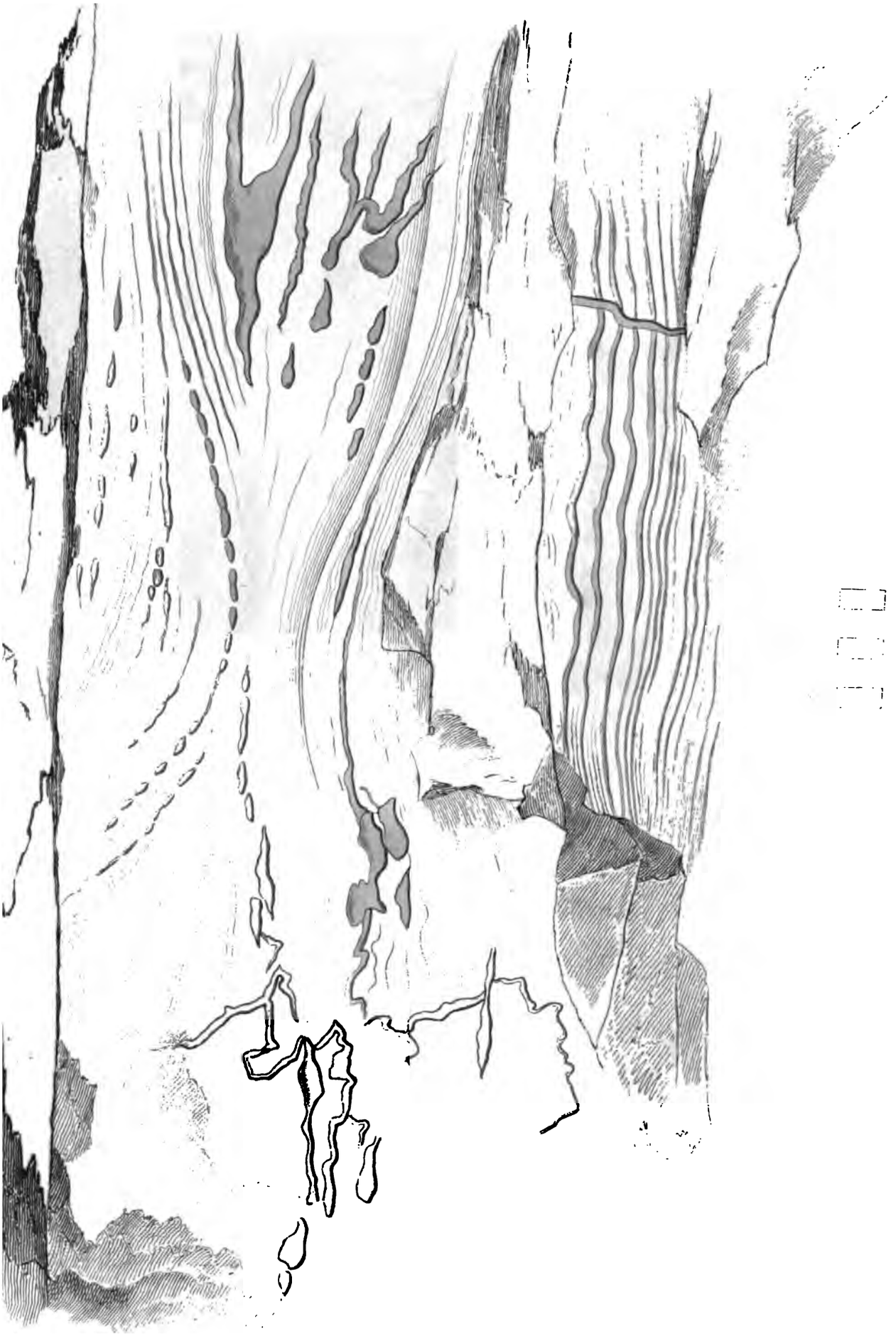

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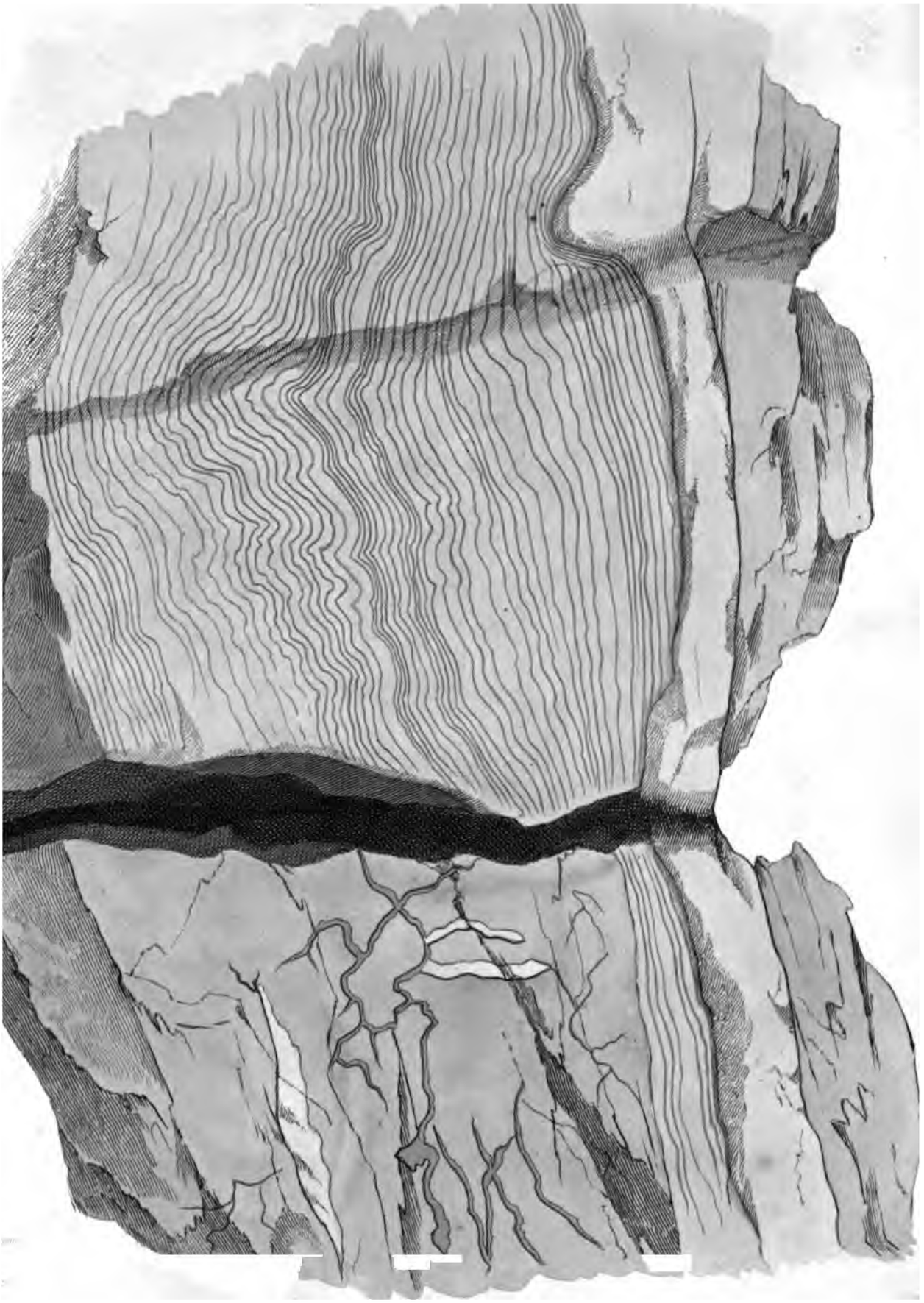

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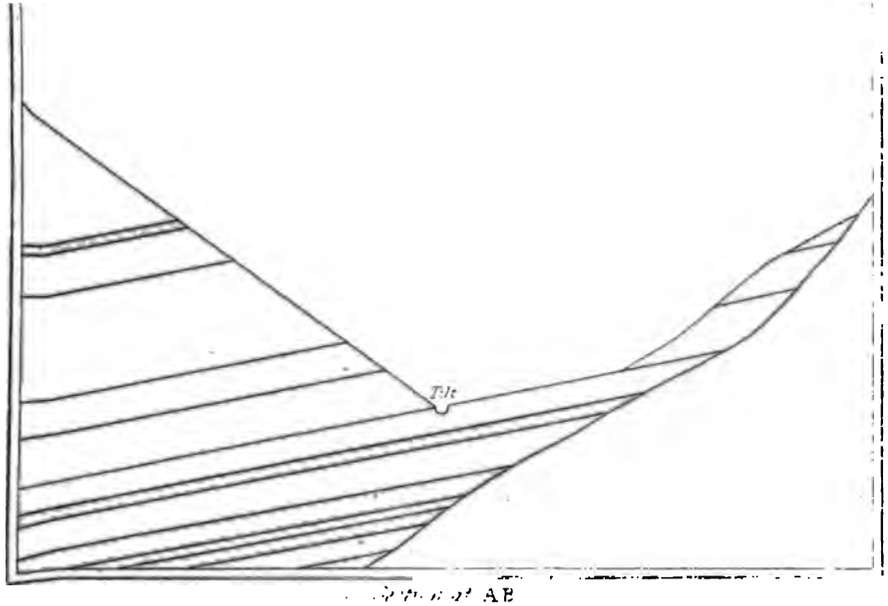
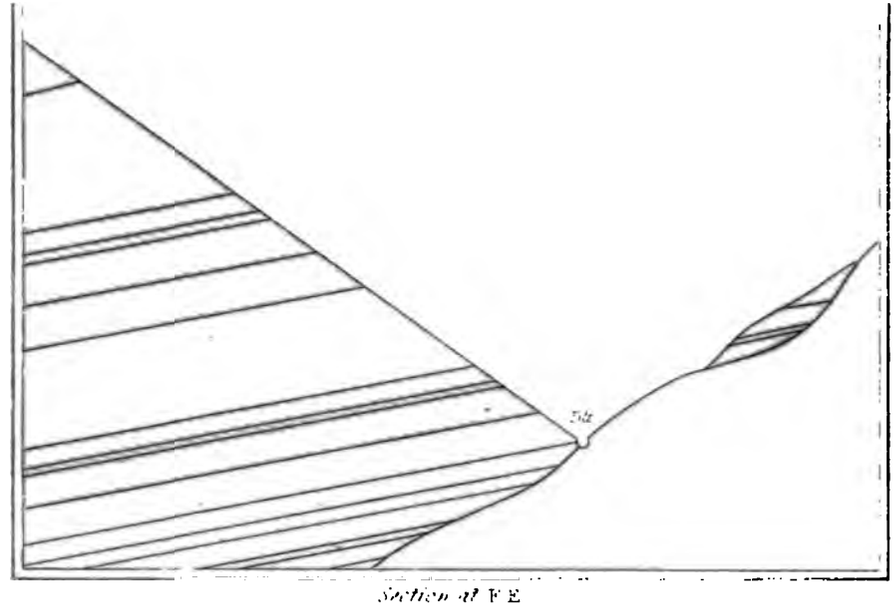
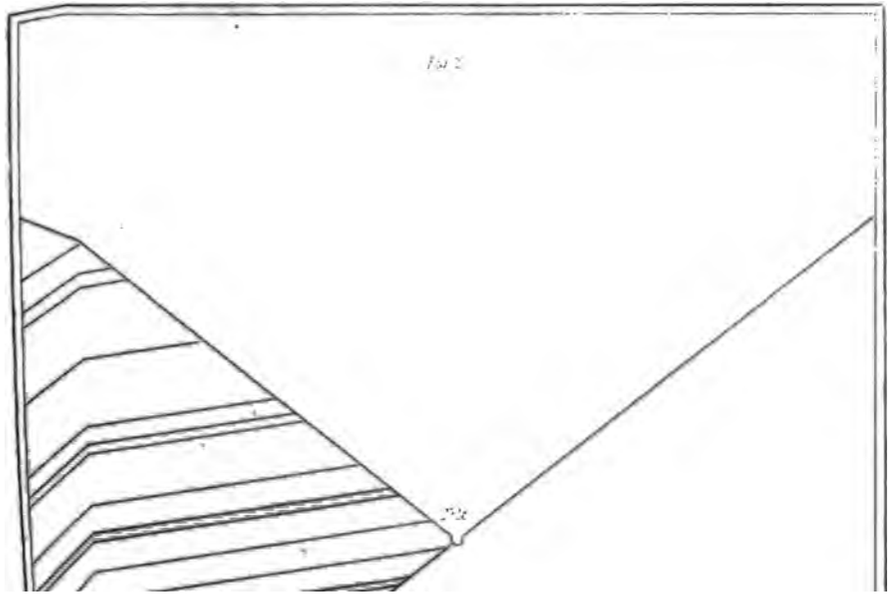
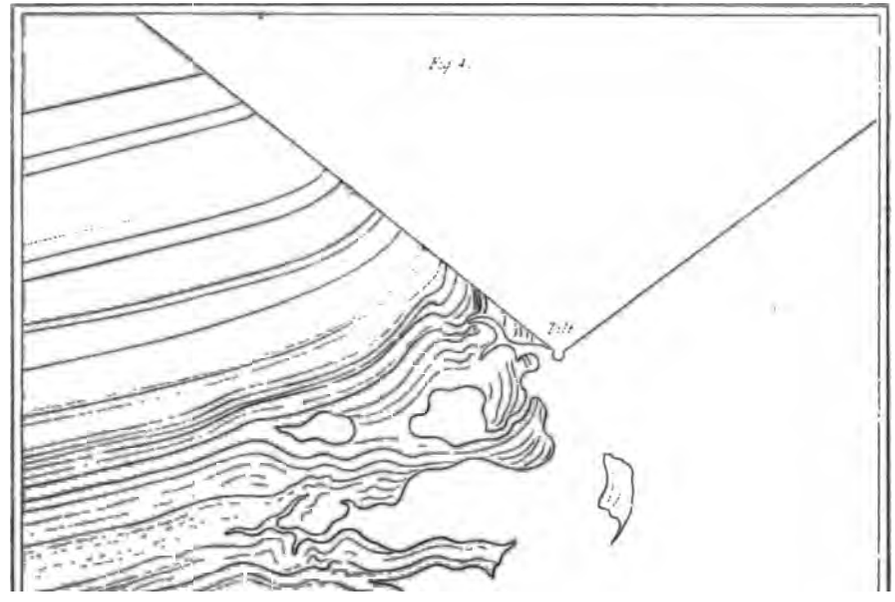


Section at AB



Section at FE





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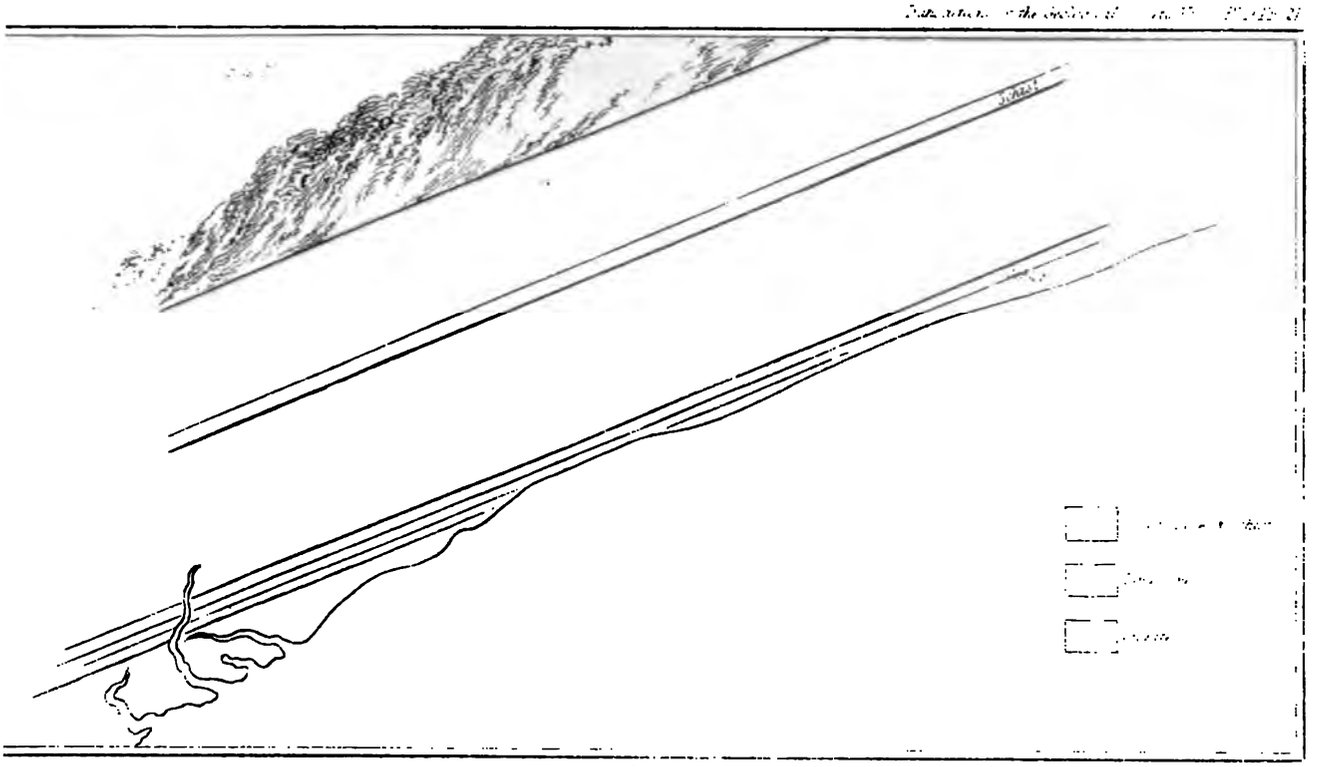


Fig 2

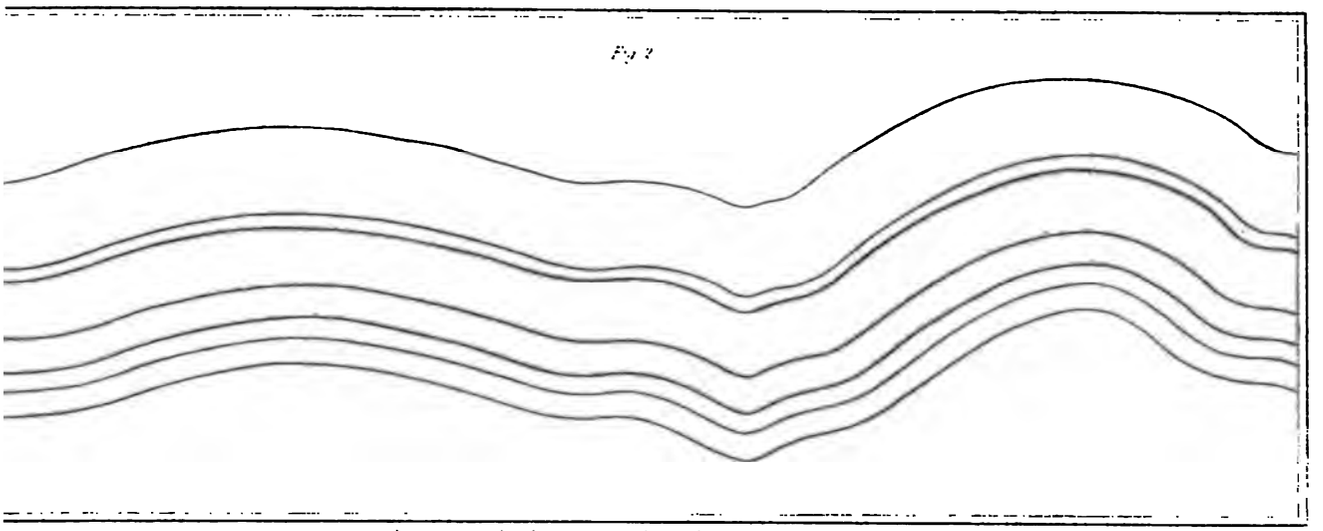
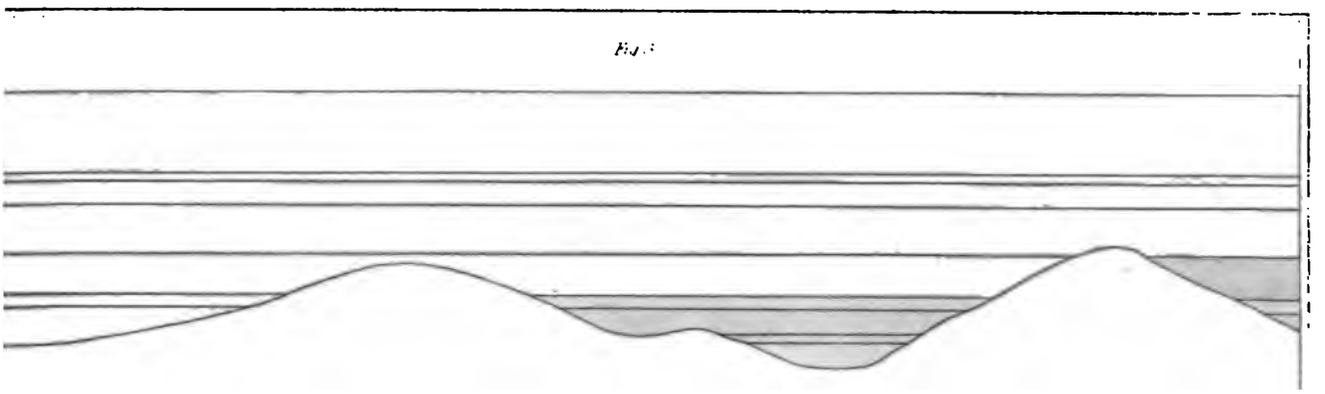


Fig 3



Actual Section at Glen Tilt from G to H.

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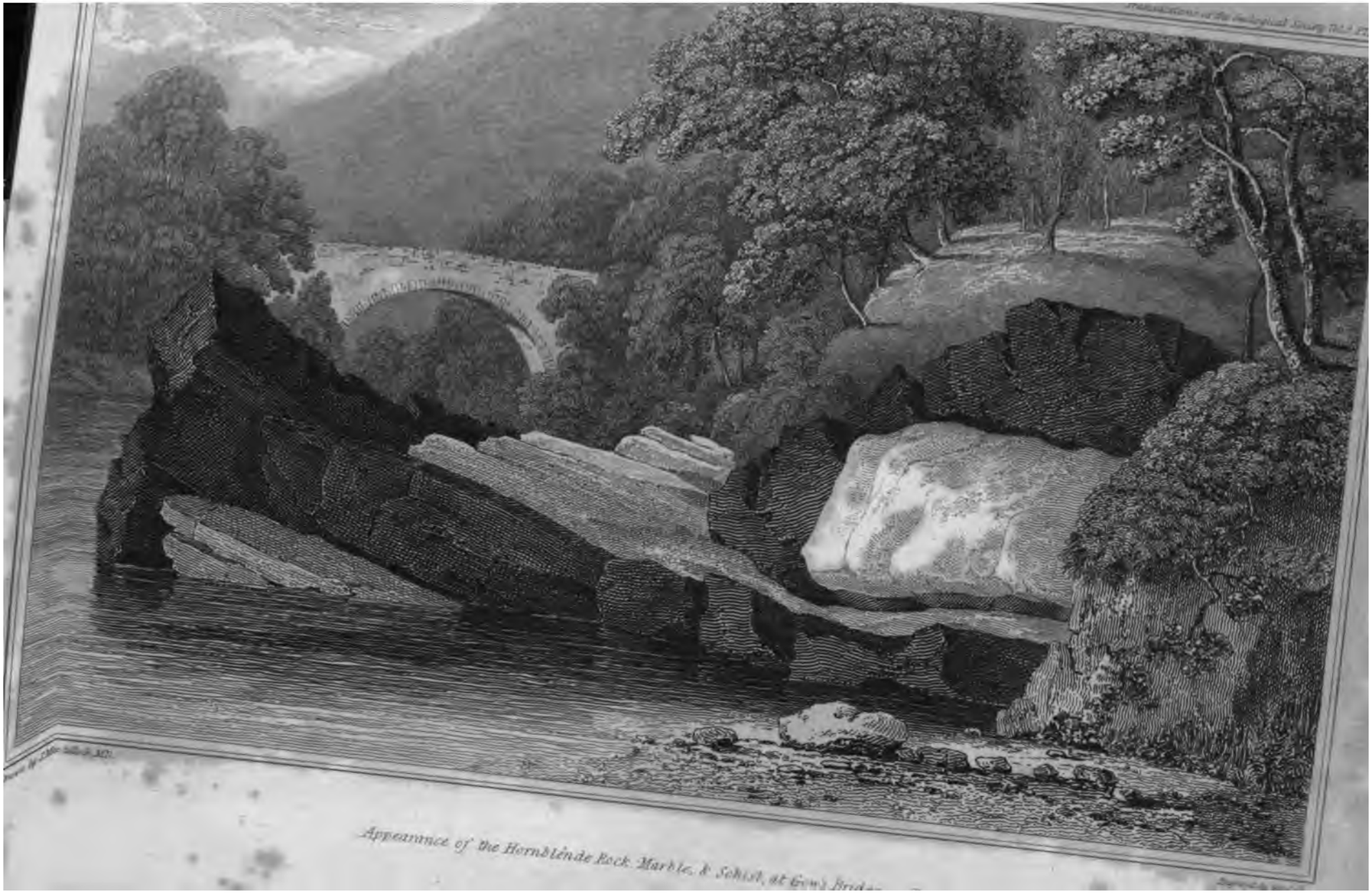

Appearance of the Hornblende Rock, Marble, & Schist, at Gow's Brid

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GEOLOGICAL MAP

of the SOUTHWESTERN PART of SOMERSETSHIRE.

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Fig. 3.

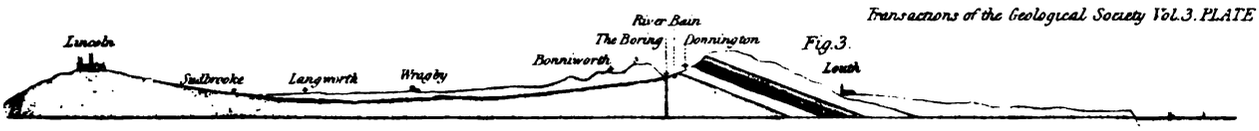


Fig. 4.

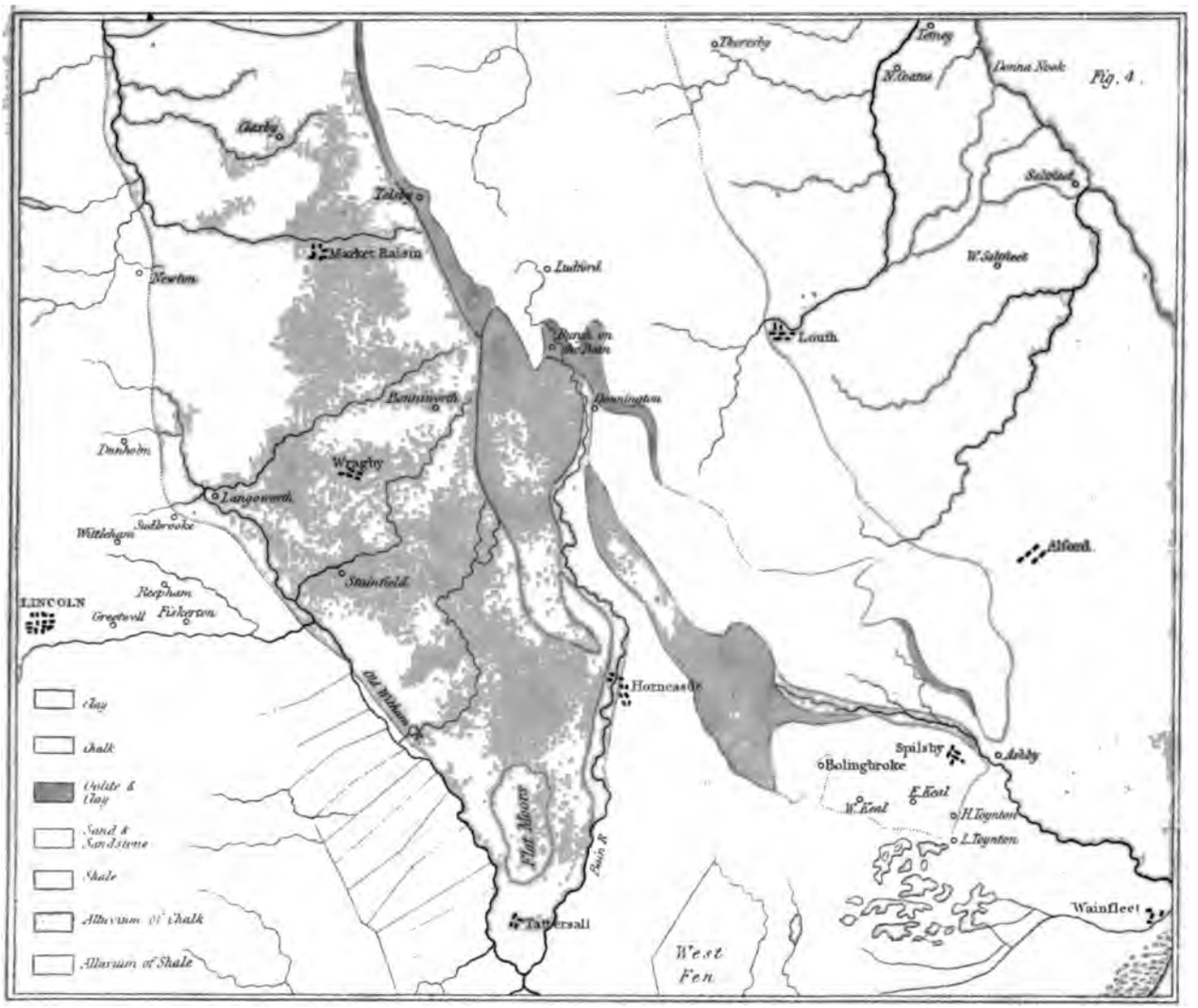


Fig. 2.

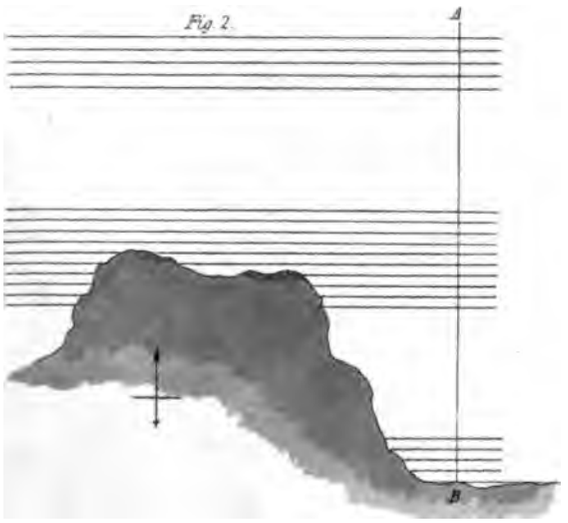
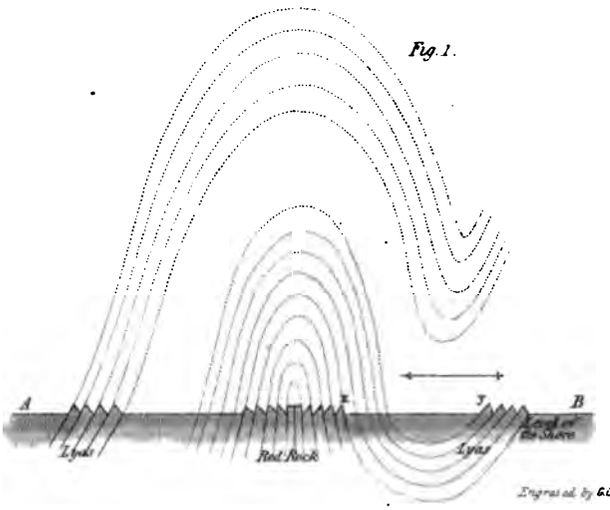


Fig. 1.



Engraved by G. Cooke.

Published by William Phillips London 1835

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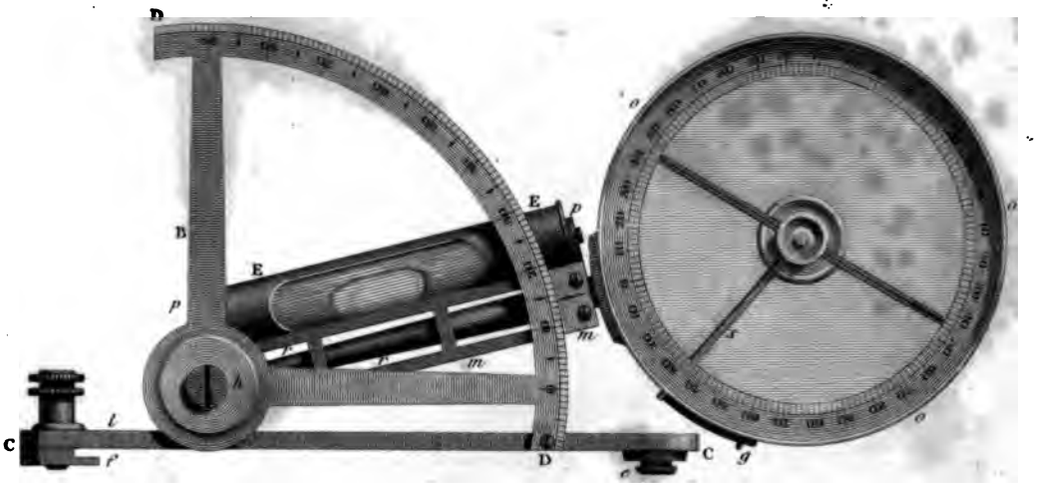

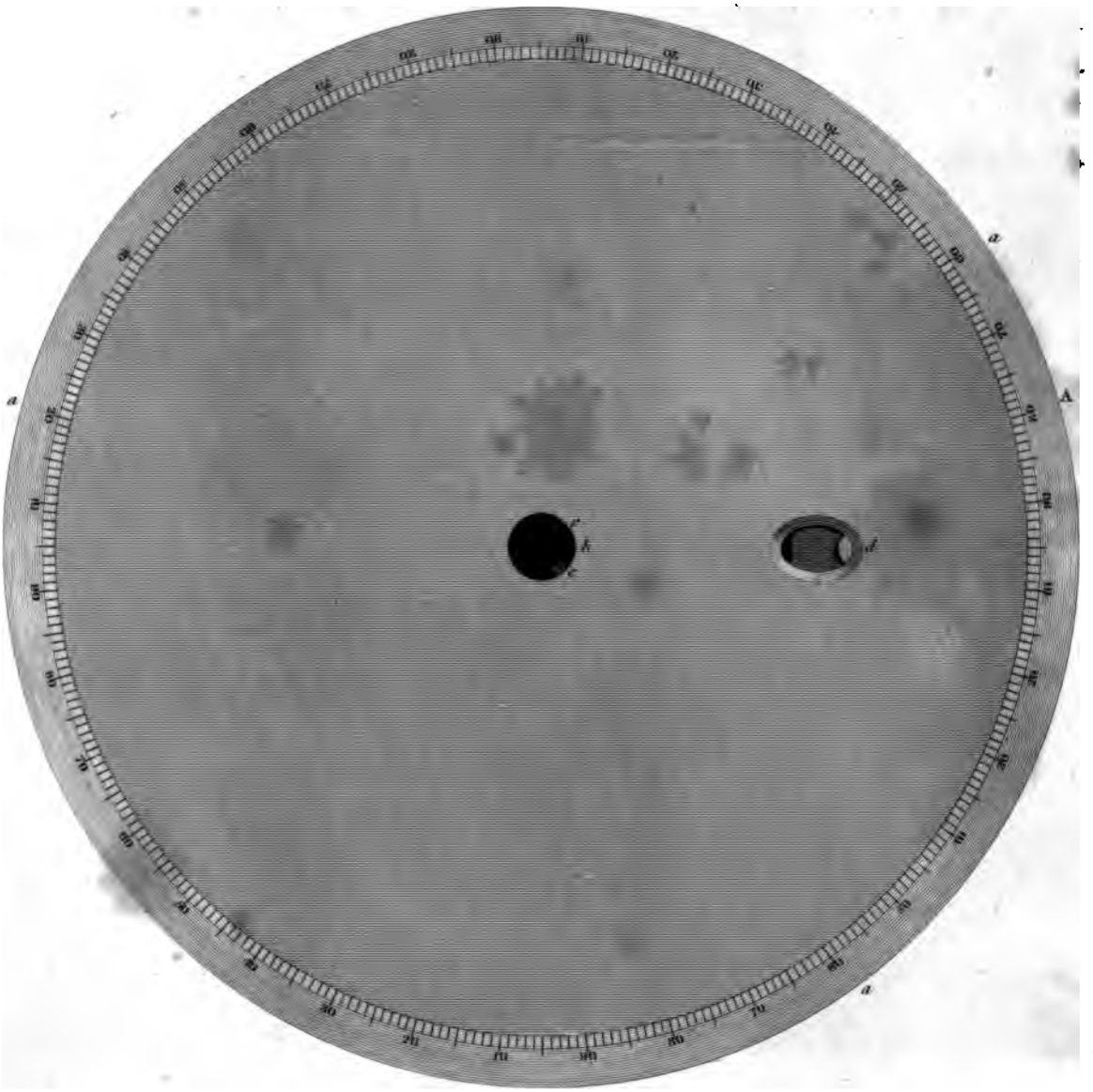

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